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AN ECONOMIC ANALYSIS OF THE FACTORS AFFECTING THE CALIFORNIA DAIRY INDUSTRY

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By
Robert A. Milligan

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AN ECONOMIC ANALYSIS OF THE FACTORS AFFECTING THE CALIFORNIA DAIRY INDUSTRY

by

Robert A. Milligan[1/]

INTRODUCTION AND OBJECTIVES

The dairy industry is an important sector of the California economy. In 1975, cash receipts from farm marketings of dairy products were $997 million in California and $9,866 million in the U. S. (California Crop and Livestock Reporting Service [1976], pp. 9-10). Approximately seventeen percent of the consumer's food budget is spent on dairy products (George and King [1971]). Producer prices are the most critical component of the retail price of dairy products and have significant ramifications for producers and consumers alike, directly affecting producers and indirectly affecting consumers. Milk prices also have nutritional implications, especially for low income families.

Of all agricultural prices, producer prices for milk are perhaps the farthest removed from the competitive market. In 1971, 95 percent of all milk meeting the requirements for fluid use was priced under state laws and/or Federal milk orders (Mathis, Friedly, and Levine [1972], p. 2). In California, the prices processors pay most milk producers are established by the California Bureau of Milk Stabilization. Although these prices are usually adopted as effective prices, officially they are minimum prices.

When the price level is established by a government agency rather than by competitive market forces, some means must be available to obtain and evaluate the information required by the decision-making body. The economist must be careful in performing economic evaluations because many conventional theories and techniques assume perfect competition. Finally,

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[1/] Assistant Professor of Agricultural Economics at Cornell University.

and probably most important, the presence of government control means that the institutional structure, often overlooked by economists assuming perfect competition, becomes a crucial component of the problem.

The overall objective of this study is to develop economic information concerning the factors that affect the day-to-day functioning of the California dairy industry. The analysis is designed with the above-mentioned restrictions in mind so that the results should be useful to those individuals responsible for establishing the price paid California milk producers. In meeting this objective, the following subobjectives are established:

1. To develop a model that delineates those variables that affect the California dairy industry. In developing this model, the prices paid to producers are controlled variables established administratively. The model then must center on determining the effects of changes in these prices.

2. To package the model so that it can be used by decision-makers in the dairy industry. Fulfilling this subobjective involves designing the model to be used with a minimum knowledge of computers and developing procedures to incorporate additional data as it becomes available.

3. To utilize the model to investigate the projected effects of important variables including milk price variables, production cost variables, retail prices of dairy products, population, and variables for changing technology and consumer tastes.

The presentation of the material generated to meet these objectives is accomplished in four major sections. The first delineates some of the important characteristics of the California dairy industry. The second section describes the economic structure of the industry in terms of the apparent relationships among price and other variables included in these relationships. The third section develops the quantitative measurements of the relationships developed in section two. In the final section these measurements are used to investigate the possible effects of alternative pricing policies and changes in other variables affecting the dairy industry.

THE CALIFORNIA DAIRY INDUSTRY

The California dairy industry is composed of four important components: the three subsectors--producer, processor, and consumer--and the milk stabilization program. Figure 1 illustrates the important relationships among the four components. The producer subsector is composed of market milk firms that meet the sanitary requirements to sell milk for fluid consumption and manufacturing milk firms that do not meet these requirements and sell milk for use only in manufactured dairy products. Therefore, processors of fluid milk products obtain their milk from market milk producers; manufactured dairy product processors purchase the remaining production of market milk firms and the production of manufacturing milk producers. Consumers purchase dairy products processed by these firms plus additional manufactured dairy products imported from other states. The Bureau of Milk Stabilization assigns quota and base to producers, sets minimum prices processors must pay market milk producers, and until recently had the authority to establish minimum wholesale and retail prices for fluid milk products.[1/] The legal aspects of milk stabilization are discussed after an examination of the three subsectors.

Producer Subsector

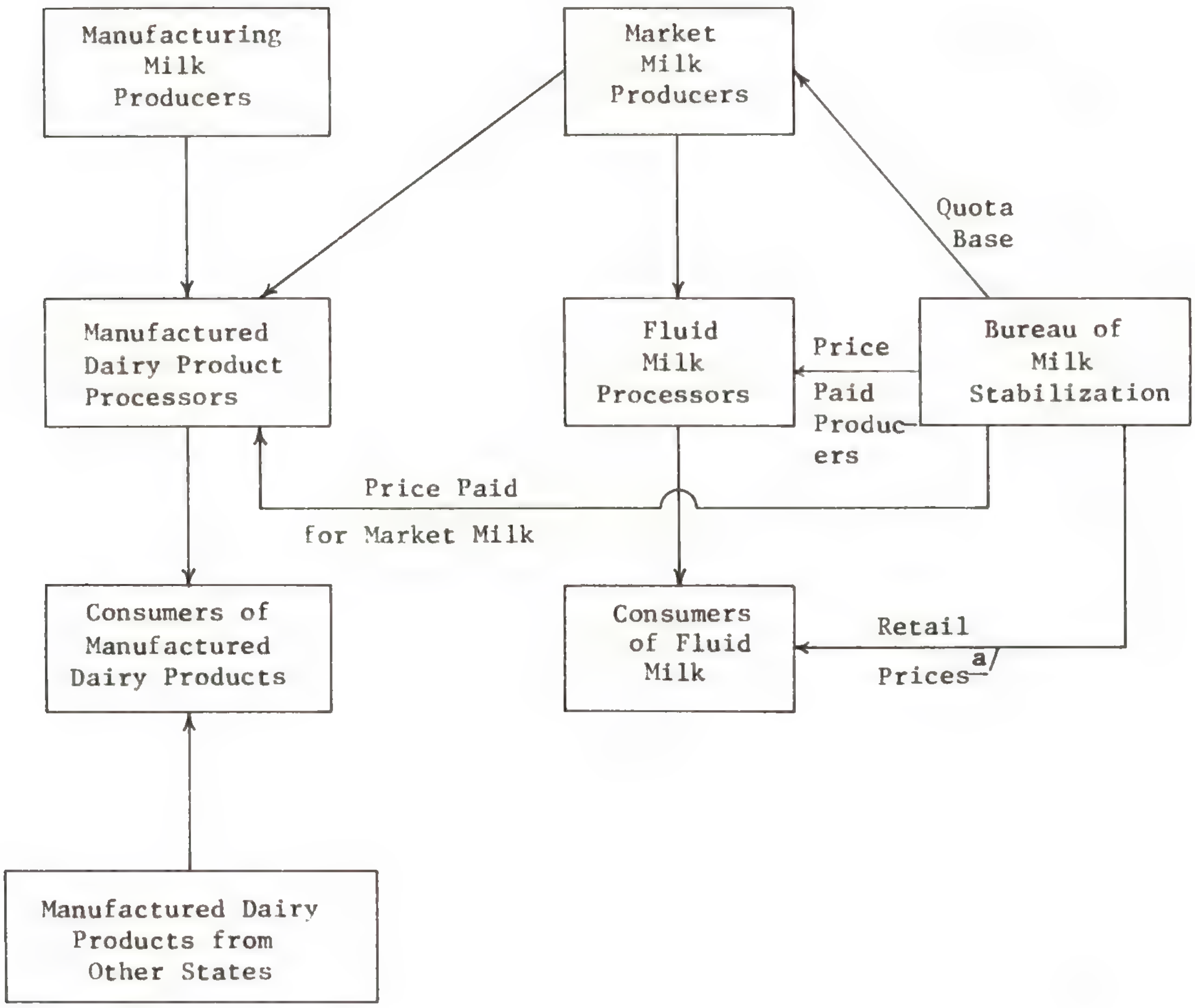
California milk production in 1975 was 10,853 million pounds, accounting for 9.4 percent of the U. S. production; only Wisconsin had greater total production (California Crop and Livestock Reporting Service [1976], p. 11). Average production per cow was 13,566 pounds, the highest of any state. Table 1 presents total California production, average production per cow, and average herd size for 1958-1975. The typical California dairy is larger and more specialized than dairies in most other states.

As indicated above, milk producing firms are of two types. The proportion of milk produced by market milk firms has increased from 35 percent in 1935 (Kuhrt [1965], p. 184) to 93 percent in 1974 (California Crop and Livestock Reporting Service [1975], p. 14). A major factor in

[1/] The State's authority to set minimum retail and wholesale prices on fluid milk products was repealed, effective January 1, 1978.

FIGURE 1

A Diagram of the Relationships Among the Four Components of the California Dairy Industry



a/ On January 6, 1977 all minimum price controls on retail prices were suspended. Effective January 1, 1978 the authority to set minimum retail prices was repealed.

TABLE 1

Total Production on Farms, Average Production Per Cow, and Average Herd Size in California, 1958-75

Year	Total production[a/] (million lbs.)	Average production per cow[a/] (pounds)	Average herd size[b/] (cows)
1958	7,586	8,730	158
1959	7,947	8,950	163
1960	8,109	9,770	166
1961	8,236	10,130	169
1962	8,316	10,330	176
1963	8,307	10,410	180
1964	8,540	10,810	185
1965	8,488	10,840	190
1966	8,569	11,100	199
1967	8,724	11,170	215
1968	8,950	11,460	225
1969	8,940	11,521	233
1970	9,494	11,957	253
1971	9,706	11,985	270
1972	10,430	13,406	294
1973	10,348	13,066	312
1974	10,601	13,301	332
1975	10,853	13,566	352[c/]

a/From California Crop and Livestock Reporting Service [1959-1976], Table 3.

b/Calculated from California Bureau of Milk Stabilization [1st quarter 1958--4th quarter 1973].

c/Estimated.

this shift has been the differential between market and manufacturing prices. This difference is larger than the additional costs required to produce market milk. Table 2 contains market and manufacturing milk prices and the share of total milk produced by market milk firms. Milk prices remained relatively constant until 1966 when a gradual increase began and continued until the substantial increases in the 1973-1975 period.

Although milk is produced in all parts of California, production is centered near large metropolitan areas and in the Central Valley. Manufacturing milk production is concentrated in the San Joaquin Valley, especially Stanislaus and Merced Counties, with additional production in the Sacramento Valley and North Coast Area. Market milk production is centered in the San Joaquin Valley and Southern California,[1/] particularly San Bernardino and Riverside Counties. In this study market milk production is separated into the five regions shown in Figure 2. The Southern California region (1) produces fluid milk for the Los Angeles area and is characterized by large, specialized dairies that purchase nearly all feed inputs and replacements. Producers in the South San Joaquin Valley (2) typically ship milk to Los Angeles from dairies that are larger and more specialized than in other parts of the Central Valley, but not as large or specialized as those in Southern California. Milk produced in the North San Joaquin and Sacramento Valleys (3) is usually shipped to the Bay Area or processed in Sacramento. In the Central Coast Area (4), milk is produced on smaller dairies primarily for consumption in the Bay Area. Production in Mountain Areas and the North Coast (5) is for local markets and has limited significance to the dairy industry of the state. These dairies are few and small. Figure 3 depicts the change in importance of the four significant regions over the last 16 years.[2/]

In 1972-74, producers were faced with rapidly escalating costs, particularly for feed inputs. In two and one-half years feed costs almost

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[1/] In 1975 85.6 percent of the market milk production was in these two areas (Calculated from California Crop and Livestock Reporting Service [1976], Table 8).

[2/] North Coast and Mountain Areas decreased slowly from 1.6 percent in 1958 to 1.1 percent in 1975.

TABLE 2

Average Price Received by Manufacturing and Market Milk Producers and Proportion of Production Produced by Market Milk Firms, 1958-1975

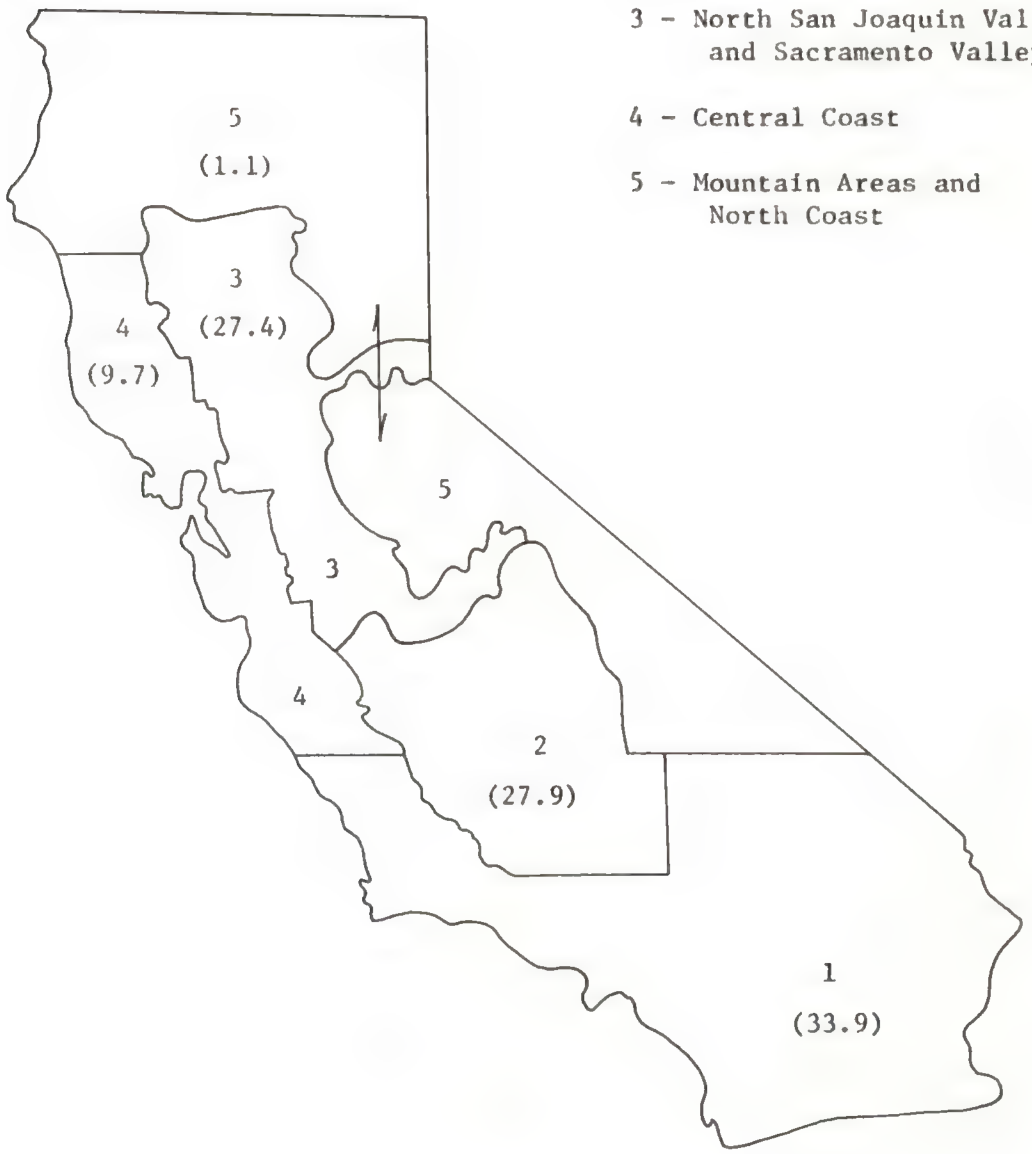
Year	Manufacturing milk price[a] ($/cwt.)	Market milk price[a] ($/cwt.)	Difference[a] ($/cwt.)	Percentage of production by market milk firms[b]
1958	3.21	4.68	1.47	79.7
1959	3.28	4.74	1.46	81.9
1960	3.20	4.77	1.57	80.2
1961	3.33	4.71	1.38	80.7
1962	3.21	4.69	1.48	81.0
1963	3.21	4.63	1.42	83.5
1964	3.39	4.60	1.21	88.2
1965	3.41	4.66	1.25	88.3
1966	3.88	4.81	0.93	89.8
1967	4.02	4.97	0.95	89.7
1968	4.12	5.11	0.99	90.8
1969	4.21	5.25	1.04	90.9
1970	4.47	5.45	0.98	90.7
1971	4.72	5.64	0.92	89.8
1972	4.83	5.70	0.87	89.0
1973	5.46	6.56	1.10	91.4
1974	6.65	8.32	1.67	93.1
1975	7.40	8.95	1.55	93.6

[a] California Crop and Livestock Reporting Service [1959-1974], Tables 22 and 23, 1958; Tables 21 and 22, 1959-1960; Tables 15 and 16, 1961-1972; Tables 14 and 15, 1973-1975.

[b] Calculated from California Crop and Livestock Reporting Service [1959-1974], Tables 25 and 27, 1958; Tables 24 and 26, 1959-1960; Table 18, 1961-1972; Table 17, 1973-1975.

FIGURE 2

Location of the Five Market Milk Production Regions in California and Percentage of 1975 Production in Each Region



1 - Southern California

2 - South San Joaquin Valley

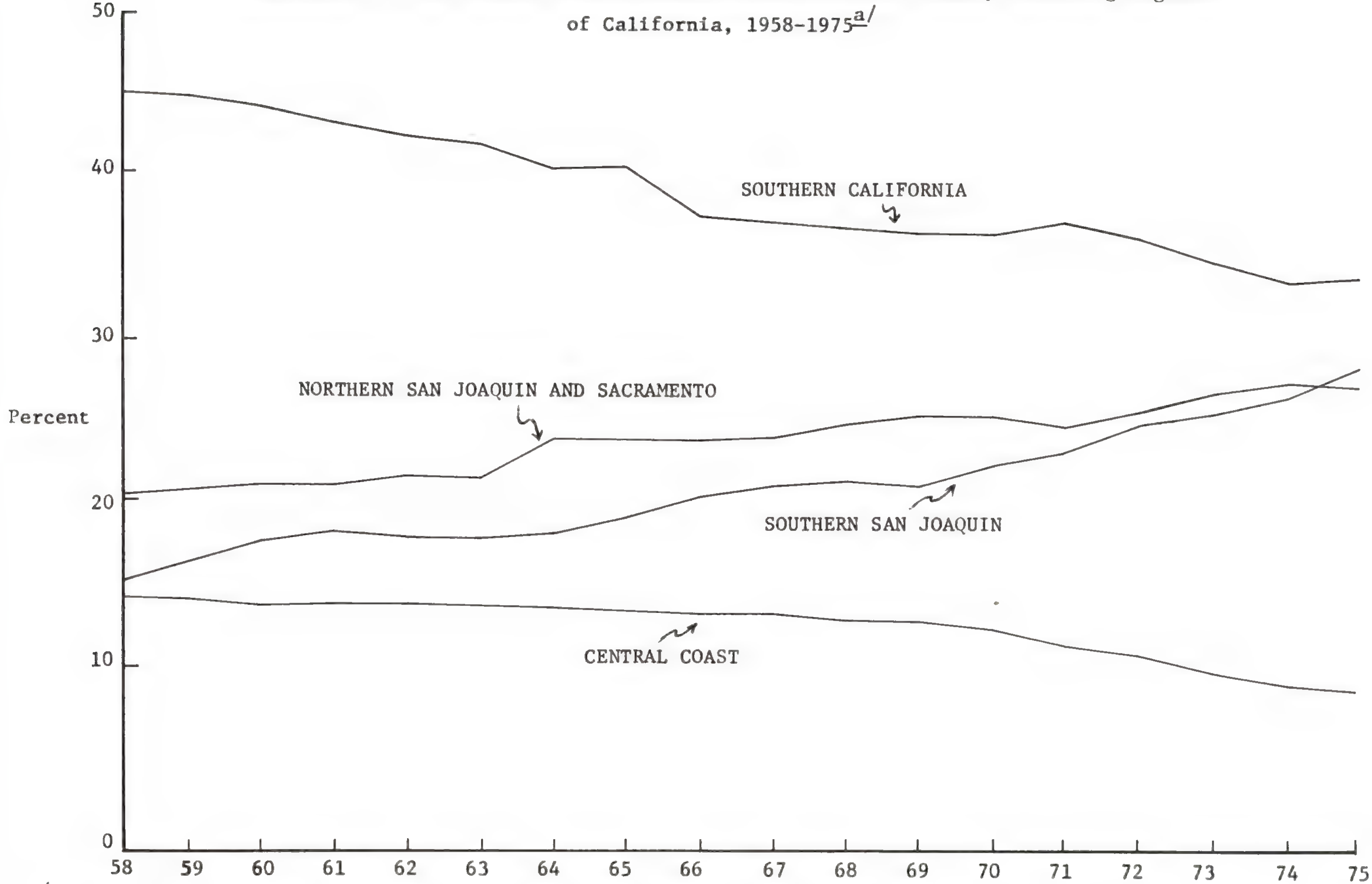
3 - North San Joaquin Valley and Sacramento Valley

4 - Central Coast

5 - Mountain Areas and North Coast

FIGURE 3

Percentage of Total Market Milk Produced in each of Four Primary Producing Regions of California, 1958-1975[a]



[a] Calculated from California Crop and Livestock Reporting Service [1959-1975], Table 7, 1958-59; Table 8, 1960-1975.

doubled. This increase is illustrated for the Southern San Joaquin region in Figure 4. These rapid increases have created considerable adjustment problems for the dairy industry.

Processor Subsector

The processor subsector is composed of two segments: fluid and manufacturing. Due to the perishability of fluid milk products, it can be assumed that fluid products are produced and processed within the state.[1/] Most manufactured dairy products, on the other hand, are sold in a national market. The exceptions are frozen dairy products and cottage cheese. Since fluid products have higher selling prices, producers are anxious to have a large proportion of their milk utilized for fluid products. Figure 5 illustrates the changes in utilization in the last eighteen years; Figure 6 reviews the percentage of production used for fluid milk. As can be seen from these figures, the quantity and the proportion of production devoted to fluid uses has declined, resulting in increased use in manufactured dairy products.

First call on milk available for manufactured dairy products is for frozen dairy products and cottage cheese because returns are somewhat higher and the relevant market is more localized due to product perishability. Milk which remains is then used for other manufactured dairy products including hard cheese, butter, and evaporated and condensed milk. Forker [1965] predicted that this residual would approach zero by 1975. Although this prediction has proven to be inaccurate, it does indicate one possible direction for the industry. Figure 7 reviews the estimated utilization of commercial milkfat produced in California.

Consumer Subsector

A downward trend in total consumption of dairy products and consumption of fluid milk has persisted for many years. Per capita consumption

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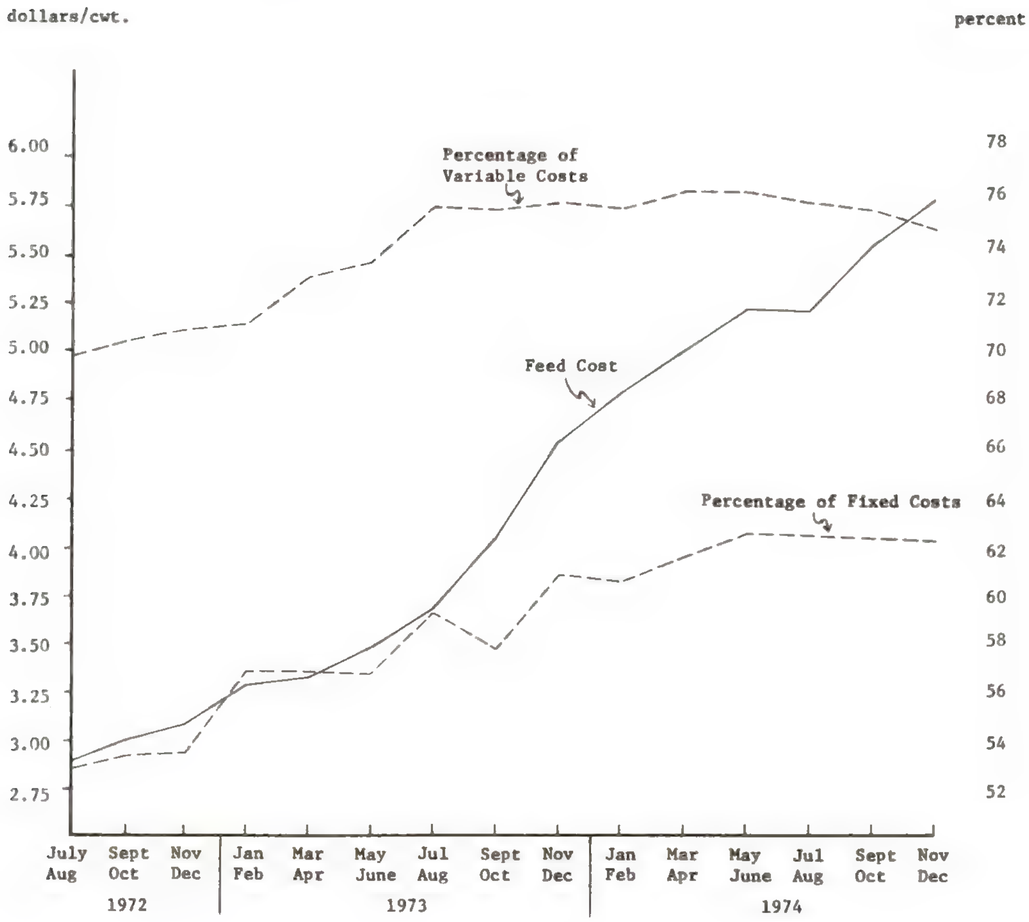
[1/] In December 1975, less than 0.1 percent of the fluid milk processed in California was sold out of the state (California Crop and Livestock Reporting Service [1976a]). The assumption is realistic because of the hauling distance due to the mountains surrounding California and would not be tenable in most states.

FIGURE 4

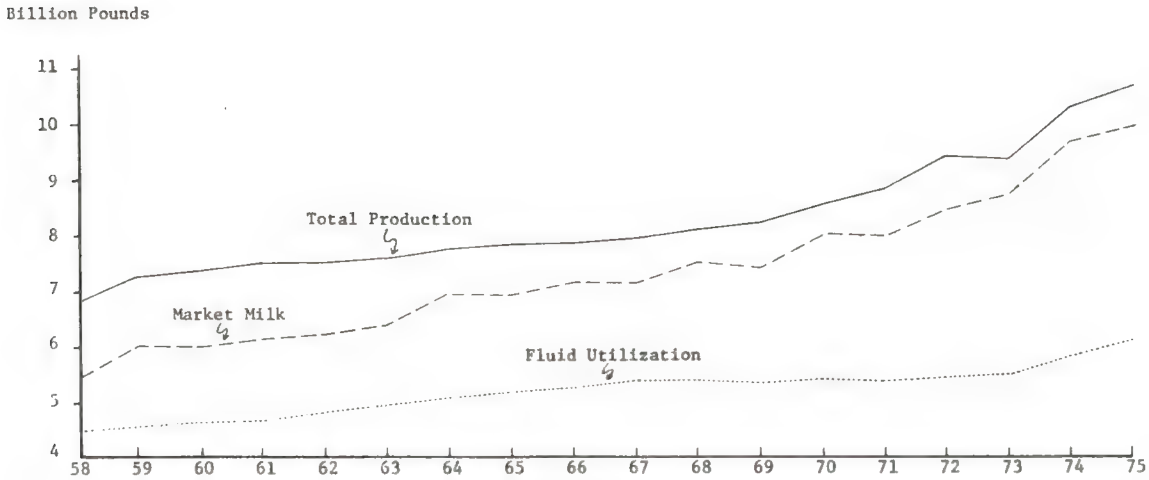
Feed Cost Per Hundredweight and as a Percent of Fixed and Variable Costs, Southern San Joaquin Valley, July 1972-Dec. 1974[a]



[a] Calculated from California Bureau of Milk Stabilization [3rd quarter 1972-November-December 1974] Southern San Joaquin Valley Production Area. The figures are averages of the producers surveyed in the region. Eighty to one hundred thirty samples were typical in this period.

FIGURE 5

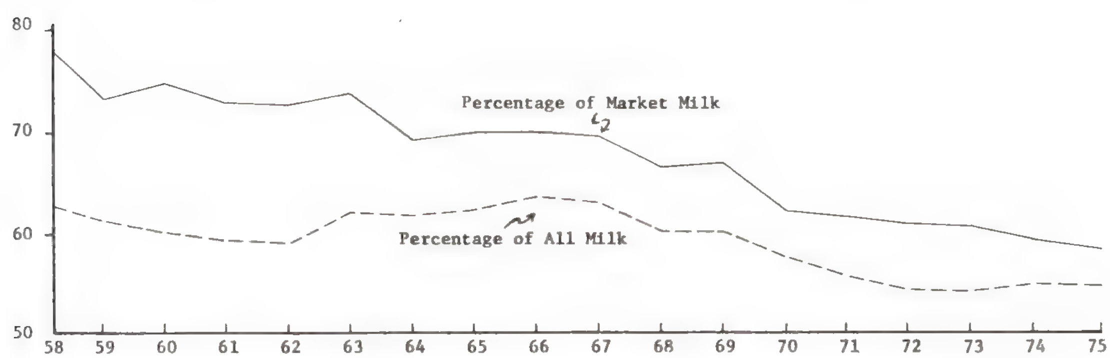
Total Commercial Production, Market Milk Production, and Fluid Utilization, 1958-1975[a]



[a] California Crop and Livestock Reporting Service [1976] Table 17.

FIGURE 6

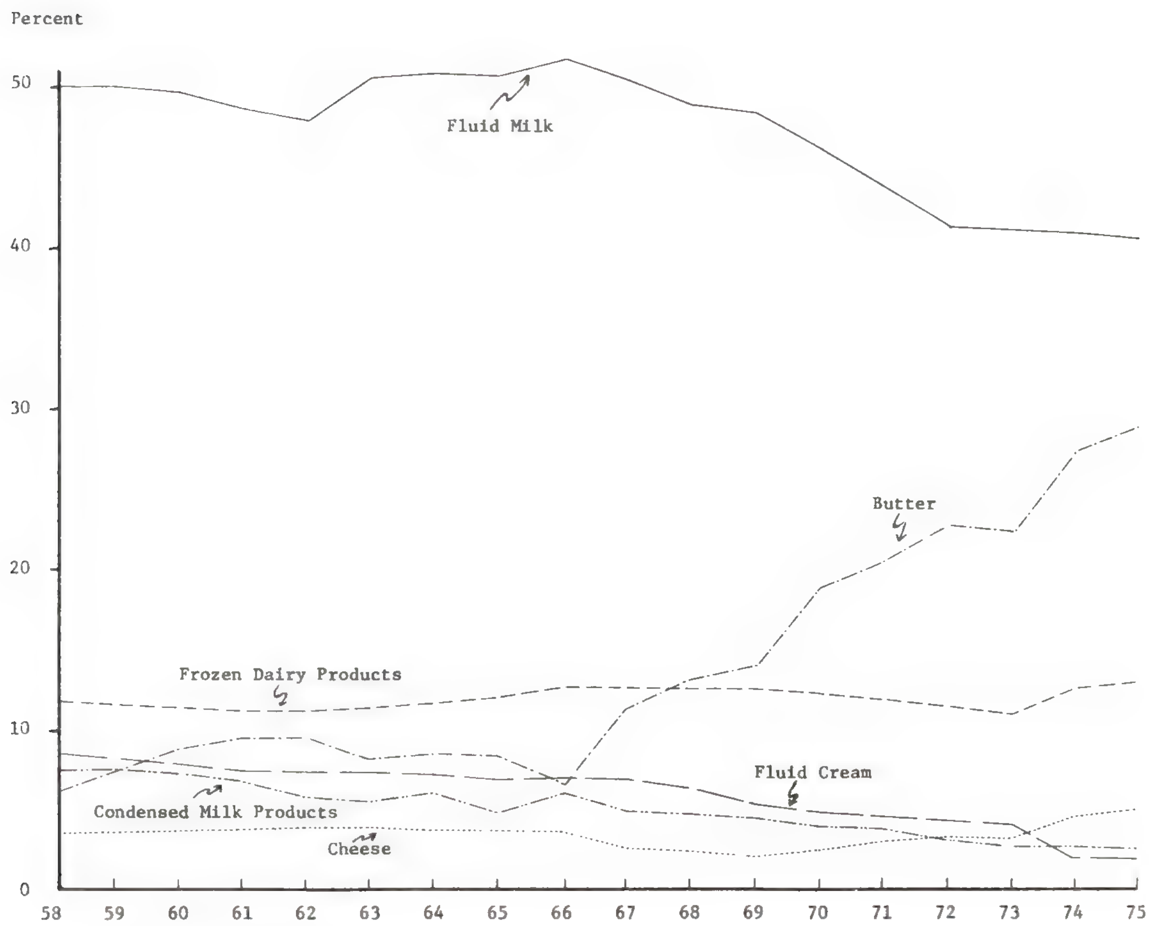
Percentage of Commercial Milk Utilized for Fluid Products, 1958-1975[a]



[a] Calculated from California Crop and Livestock Reporting Service [1976], Table 17.

FIGURE 7

Estimated Utilization of Commercial Milkfat Produced in California, 1958-1975[a/]



a/ From California Crop and Livestock Reporting Service [1976], Table 16. Other manufactured dairy products accounted for 4.2 to 6.5 percent of the milkfat.

for California can be estimated accurately for the perishable products that are processed for a local market: fluid products, cottage cheese, buttermilk, and frozen dairy products. Table 3 shows the trend in consumption of these products. Consumption of fluid milk and buttermilk has steadily declined. Only U. S. consumption data are available for the remaining manufactured dairy products and are presented in Table 4.

Consumers, as well as producers, have been adversely affected by increased feed costs since these increased costs have been reflected in increased retail prices. Consumer groups have responded by severely criticizing the milk stabilization program. These groups have demanded and received representation at the hearings called to consider price increases.[1/] As a result of consumer pressure on state legislators, the Senate Committee on Agriculture and Water Resources has held lengthy hearings on milk stabilization, numerous bills have been introduced in the State Legislature, and the authority to establish minimum wholesale and retail prices on fluid milk products has been repealed.

Milk Stabilization Program

Clarke [1961, 1968] has argued that due to special characteristics of the dairy industry some form of price control is necessary to avoid an unstable market. The characteristics mentioned are:

1. The nature of the product; there are no close substitutes.
2. The bargaining disparity created by the industry structure of many producers and few distributors and retailers.
3. The continuous buyer-seller relationship along with the perishability of milk can force the producer to take almost any price that is offered.

Prior to the depression of the 1930's, producer organizations exerted sufficient price control to maintain reasonable stability in

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[1/] The mechanism for price increases is discussed in the following section.

TABLE 3

Estimated Per Capita Consumption of Selected Dairy Products in California, 1958-1975[a]

Year	Fluid products (quarts)	Cottage cheese (pounds)	Buttermilk (quarts)	Frozen products (quarts)
1958	145.89	8.19	4.47	23.50
1959	144.72	8.27	4.23	23.67
1960	140.85	8.18	3.99	22.98
1961	136.85	7.77	3.75	22.99
1962	135.32	7.50	3.54	23.23
1963	136.02	7.47	3.49	23.43
1964	137.12	7.43	3.36	24.04
1965	133.99	7.34	3.25	24.52
1966	134.80	7.14	3.13	24.69
1967	131.88	7.14	2.97	24.23
1968	129.72	7.25	2.83	24.47
1969	126.87	7.55	2.86	24.07
1970	125.41	8.26	2.93	24.02
1971	123.81	8.34	2.96	23.34
1972	128.01	8.24	2.94	23.49
1973	128.34	7.88	2.78	22.73
1974	127.85	7.16	2.51	23.67
1975	128.60	6.84	2.42	23.96

[a] From California Crop and Livestock Reporting Service [1976] Table 64.

TABLE 4

Per Capita Consumption of Selected Manufactured Dairy Products in the United States, 1958-1975[a/]

Data	Butter (pounds)	Hard cheese (pounds)	Evaporated & condensed milk (pounds)	Dry milk products (pounds)	Total milk solids (pounds)
1958	8.3	8.1	19.0	6.8	69.4
1959	7.9	8.0	19.0	7.3	68.8
1960	7.5	8.3	18.2	7.3	67.9
1961	7.4	8.6	18.1	7.3	67.0
1962	7.3	9.2	17.3	7.3	66.9
1963	6.9	9.2	16.1	7.0	65.7
1964	6.9	9.4	16.1	7.2	66.0
1965	6.4	9.6	15.7	7.0	65.6
1966	5.7	9.8	15.1	7.3	64.7
1967	5.5	10.1	14.0	7.1	63.0
1968	5.7	10.6	13.7	7.2	63.0
1969	5.4	11.0	12.8	7.2	62.6
1970	5.3	11.5	12.1	6.8	61.7
1971	5.1	12.2	11.9	6.8	62.2
1972	4.9	13.2	11.1	6.7	62.8
1973	4.8	13.7	10.3	7.4	62.6
1974	4.6	14.6	9.1	6.6	61.2
1975[b/]	4.8	14.5	8.9	5.7	61.1

[a/]Data for 1958-1959 are from Hiemstra [1968], for 1960-1975 are from U. S. Department of Agriculture [1976].

[b/]Preliminary.

California milk markets.[1/] With the diminished demand during the depression, producer organizations lost almost all effectiveness. By the early 1930's the situation was chaotic. Price wars were common with the store price of milk falling to as low as one cent per quart. Most of the price decline was passed back to producers; instances of producers not being paid at all were common.

By mid-1932 the situation had deteriorated to the point where violence was feared, particularly in the Los Angeles milkshed. After an urgent appeal to the Governor by producers, officials of the Division of Markets were able to mediate an agreement which brought reasonable although tenuous stability to the Los Angeles area. After Congress passed the Agricultural Adjustment Act of 1933, milk officials in Los Angeles and other California markets applied for Federal orders; however, within a year the courts ruled the program could not be enforced as milk production in California was local in nature and not a part of interstate commerce.

In 1935, a bill to establish minimum producer prices, the Young Act, easily passed the State Legislature and was signed by the Governor. Under this program the Director of Agriculture could establish minimum producer prices for market milk upon approval of market milk producers representing 65 percent of their number and of the production in an established marketing area. Pricing of manufacturing milk was not included in the legislation. The basic legislation remains in effect although amendments to update and modify the procedures have been enacted in nearly every legislative session. All producing areas have voted to be in the program. In 1937 passage of the Desmond Act extended minimum price control to wholesale and retail prices of fluid milk products.[2/]

Although the Young and Desmond Acts and their amendments are the basis of the California Milk Stabilization Program, action taken

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[1/] The history of milk stabilization in California is discussed by Kuhrt [1965] and in great detail by Tinley [1938], especially chapters one through three. The discussion in this section emanates from these sources.

[2/] See footnote 1, page 3.

under Federal legislation also affects the California dairy industry. Therefore, a brief review of the Federal milk stabilization program is included prior to a more detailed discussion of the California milk stabilization program.

The Federal Milk Program[1/]

Federal regulation related to the dairy industry is contained in two programs. The first is known as the "Dairy Price Support Program". This program was developed to carry out provisions of the Agricultural Act of 1949 requiring that the price of manufacturing milk and certain of its products be supported at between 75 and 90 percent of parity. The second, the "Federal Milk Marketing Order Program", is designed to implement the provisions of the Agricultural Marketing Agreement Act of 1937. Its purpose is to establish the minimum differential between the producer price of manufacturing milk in Minnesota and Wisconsin and the price paid for milk used in fluid products in any area of the country which has voted to join this program (Federal order market). The minimum price paid producers in these Federal order markets for milk used in fluid products is then the Minnesota-Wisconsin manufacturing milk price plus the differential established by the Secretary of Agriculture. This program does not significantly affect the California dairy industry.

The price support program, on the other hand, has an important impact on the California dairy industry since most manufactured dairy products compete in a national market. Under this program, the Secretary of Agriculture announces a support price for manufacturing milk, butterfat (in farm-separated cream), butter, cheddar cheese, and nonfat dry milk. The price for manufacturing milk and butterfat is the minimum that can be paid producers; the support for the three products is maintained by Commodity Credit Corporation purchases of all excess production. Because of ease of diverting milk among products, these purchases effectively establish a floor under the price of all manufactured dairy products.

[1/] The discussion in this section is based on the material in Vial [1972].

The California Milk Stabilization Program[1/]

The objectives of milk stabilization as recorded in the Agricultural Code [1969, Division 21, Part 3, Chapter 2, Article 4] are:

1. To maintain an adequate supply of pure and wholesome milk.
2. To eliminate unfair and destructive trade practices which tend to undermine the quality and availability of milk to the inhabitants of the state.
3. To promote and maintain efficiency, stability, and reasonable prosperity in the milk industry.

In meeting these objectives, the Bureau of Milk Stabilization and the Director of Food and Agriculture have exercised four types of control:

1. Set minimum (usually adopted as effective) prices to be paid by distributors to market milk producers.
2. Set minimum wholesale and retail prices for fluid milk products.[2/]
3. Determine the location differentials for quota milk.
4. Calculate the base and quota for each producer.

Minimum prices to be paid by distributors are established by components for four classes of market milk. These four classes are based upon utilization of the milk as specified in the Agricultural Code [1969, Division 21, Part 3, Chapter 2, Article 3]:[3/]

1. Class 1 comprises all fluid milk, fluid skim milk, or fluid cream supplied to consumers as fluid milk, fluid low fat, fluid skim, half-and-half, and yogurt.

[1/] The legal basis for milk stabilization is contained in Division 21, Part 3, Chapters 2 and 3 of the Agricultural Code of California [1969].

[2/] See footnote 1, page 3.

[3/] This interpretation of the lengthy legal description in the code follows Kuhrt [1965]. Specific product references are from the California Department of Food and Agriculture [1974]. A complete classification is available in the California Department of Food and Agriculture [1974, p. 14].

2. Class 2 comprises any fluid milk, fluid skim milk, or fluid cream which is used in the manufacture of any product not included in class 1, class 3, or class 4. Commonly used products are the heavy creams, cottage cheese, and sterilized milk products.

3. Class 3 comprises all fluid milk, fluid skim milk, or fluid cream which is used in frozen dairy products.

4. Class 4 comprises all fluid milk, fluid skim milk, or fluid cream used in the manufacture of butter, hard cheese, and nonfat dry milk powder.

5. In addition, the condensed and evaporated milk products shall be assigned to the classification of ultimate usage.

Class 1 and some class 2 products (the heavy creams and cottage cheese) must be made from market milk.[1/] Processors of the remaining products can use market or manufacturing milk.

The Bureau employs component pricing, whereby producers are paid for the milk fat and solids-not-fat content of their milk. Only in class 1 is any value attributed to the residual liquid carrier. Because of competition with manufacturing milk and the national market for most manufactured dairy products, class 2, class 3, and class 4 prices must be in line with prevailing prices throughout the country. At the present time class 4 milk fat price is determined by a formula based on either the butter price on the Chicago Mercantile Exchange or the Federal support price for butter in California. Each price is adjusted for processing and transportation costs, and the larger of the two prices is used. Similarly, the solids-not-fat price is based on either a weighted average price for nonfat dry milk f.o.b. California plants or the Federal support price for nonfat dry milk.[2/] Class 2 and class 3 prices are determined by addition of a predetermined differential to the preceding month's class 4 price.

[1/] The requirement that certain class 2 products must be made from market milk was implemented January 1, 1974. This requirement should have little influence on this study because of the large volume of market milk available for manufactured products.

[2/] Further details including some history and an example are contained in the California Department of Food and Agriculture [1974].

Minimum class 1 prices are announced by the Director of Food and Agriculture after consideration of the testimony of interested parties at one or more public hearings. Because almost all class 1 milk products are produced and marketed within the state, California market conditions are given primary consideration in this decision process. Supply and demand factors, milk production costs, and price stability considerations are evaluated, but no precise formula exists with weights for these and other factors.

Once the above classified prices are established, actual producer returns depend on the statewide proportion of market milkfat and solids utilized in each product class. Producers were formerly paid according to utilization in the milk processing plant to which they shipped. However, the Gonsalves Milk Pooling Act passed in 1967 authorized statewide pooling to overcome inequities arising from the individual handler pooling system.[1/]

Under this system, each market milk producer was assigned a production base for fat and solids equal to average daily production in 1966 or 1967 (the base years). The class 1 portion of the base year shipments, increased by 10 percent, became the producer's quota. New quota is allocated whenever there is an increase in class 1 sales, with 20 percent going to new producers and the remainder to existing producers. The largest allocations are given to dairymen with the lowest quotas relative to their production base.

Each producer is paid a blend price determined by the relative amounts of his production sold as quota, base (production base minus quota), and overbase (shipments over production base) fat and solids.[2/] As illustrated in Figure 8, the value for quota payments is derived from the highest valued uses of the milk. The value from milk utilized in all class 1 and some class 2 products is usually required to meet quota payments. After the value is allocated to quota, the value of

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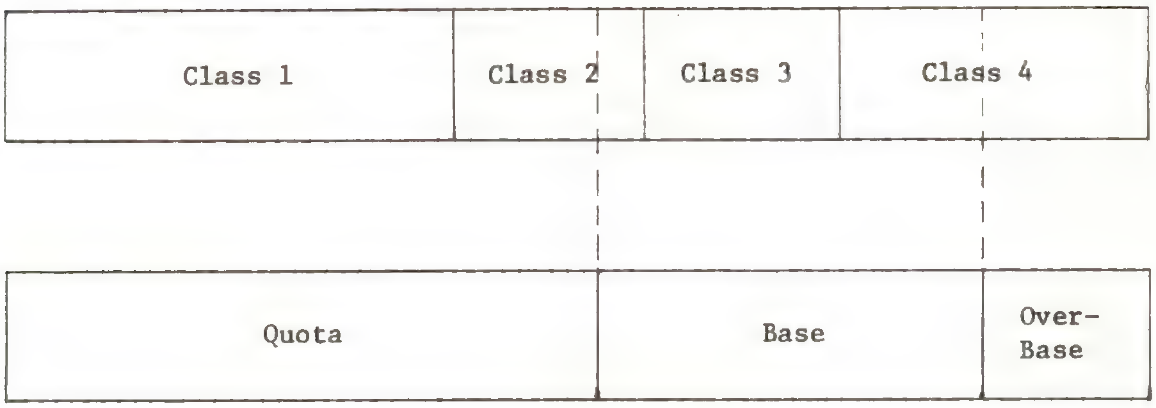
[1/] Discussion of the inequities of individual plant pools and development of the statewide pool can be found in Kuhrt [1972], Ortego, Forker, and Courtney [1967], and California Agricultural Experiment Station [1964].

[2/] Details of the allocation of quota and production base are detailed in California Department of Food and Agriculture [1974] and California Department of Food and Agriculture [1973].

FIGURE 8

Illustration of the Procedure for Determining
Quota, Base, and Overbase Prices



the highest valued classes remaining is allocated to the base price. The allocation to quota and base have always required all utilization in classes 1-3 and some of the utilization in class 4; consequently, the overbase price has been the same as the class 4 price. These calculations are executed independently for milkfat and solids-not-fat.

The only adjustment to the above procedure is for location differentials. These adjustments are applied to quota only and are based on the location of the plant that first receives the milk. They are designed to encourage producers to make milk available to plants in areas with large fluid consumption, namely the Los Angeles and San Francisco areas.

Until recently, the Milk Stabilization Program had the power to establish minimum wholesale and retail prices for class 1 products. The general procedure was to pass price increases at the farm level on to consumers keeping the margin constant. Adjustments in margins were made when other costs changed. In January 1977, all minimum wholesale and retail prices were suspended. Effective January 1, 1978, the authority to establish minimum prices was repealed. Minimum prices can be reimposed for no more than 90 days under conditions of severe market disruption.

Evaluation of Milk Stabilization

On two occasions, in the mid-fifties and again in the mid-sixties, extensive evaluations of the milk stabilization program have been conducted. The results have been reported in California Agricultural Experiment Station [1964], Clarke [1955], Hammerberg [1965], Ortego, Forker, and Courtney [1967], Revzan [1965], and Warner [1965]. In each case the results were generally favorable, finding that prices were in line with those in other areas of the country. Ortego, Forker, and Courtney [1967] using cross-sectional (analysis of covariance) and comparative analysis found class 1 prices to be about the same as in uncontrolled markets and markets under Federal milk orders. The price level in California was found, however, to be somewhat lower than in other state controlled markets. In both evaluations, actual and potential areas of inefficiency were exposed. Many of these have been corrected by subsequent legislation.

More recent comparisons are made in California Department of Food and Agriculture [1974]. This report indicates that class 1 prices in California have been below the average of all Federal Milk Marketing Areas since 1966. In May 1974 the differential was 44 cents. Furthermore, the marketing margin is found to be less than the average of 19 other cities as of February 1974.

In spite of the information provided by comparative analyses of this type, three inadequacies are present. First, the analysis concerns past prices and may rapidly become dated. This problem is aggravated by the current price instability. Second, due to the various forms of price controls, few even approximately competitive milk markets remain for comparison. Finally, such comparisons may be of limited value. The prices should be based on supply-demand conditions which are not necessarily equivalent in the regions compared. It is possible that a lower California price is required to generate producer profits equal to other regions due to the favorable climate and the institutional structure that has resulted in large, efficient producing units.

One attempt at overcoming these problems was a simulation model of fluid aspects of the California dairy industry. Desai [1968] simulated four institutional arrangements including the present arrangement,[1/] a similar arrangement with class 1 prices tied to Midwest prices, a nationwide pooling scheme, and an unregulated industry. The author concludes that the alternative systems can achieve lower producer and retail prices.

THE STRUCTURE OF THE CALIFORNIA DAIRY INDUSTRY

The first step in delineating the effects of the key variables on producers, processors, and consumers in the California dairy industry is to develop a representation of the underlying economic structure of the industry. Included in the "structure" are relationships between costs, prices, and quantities produced or sold in the producer, processor, and consumer subsectors of the industry.

This section commences with a graphical outline of the structure of the industry. Following an overview of the relationships in the system, each equation or set of equations is described and discussed. The result of this section is a system of relationships that can be used to measure the effects of the specified variables on producers, processors, and consumers in California.

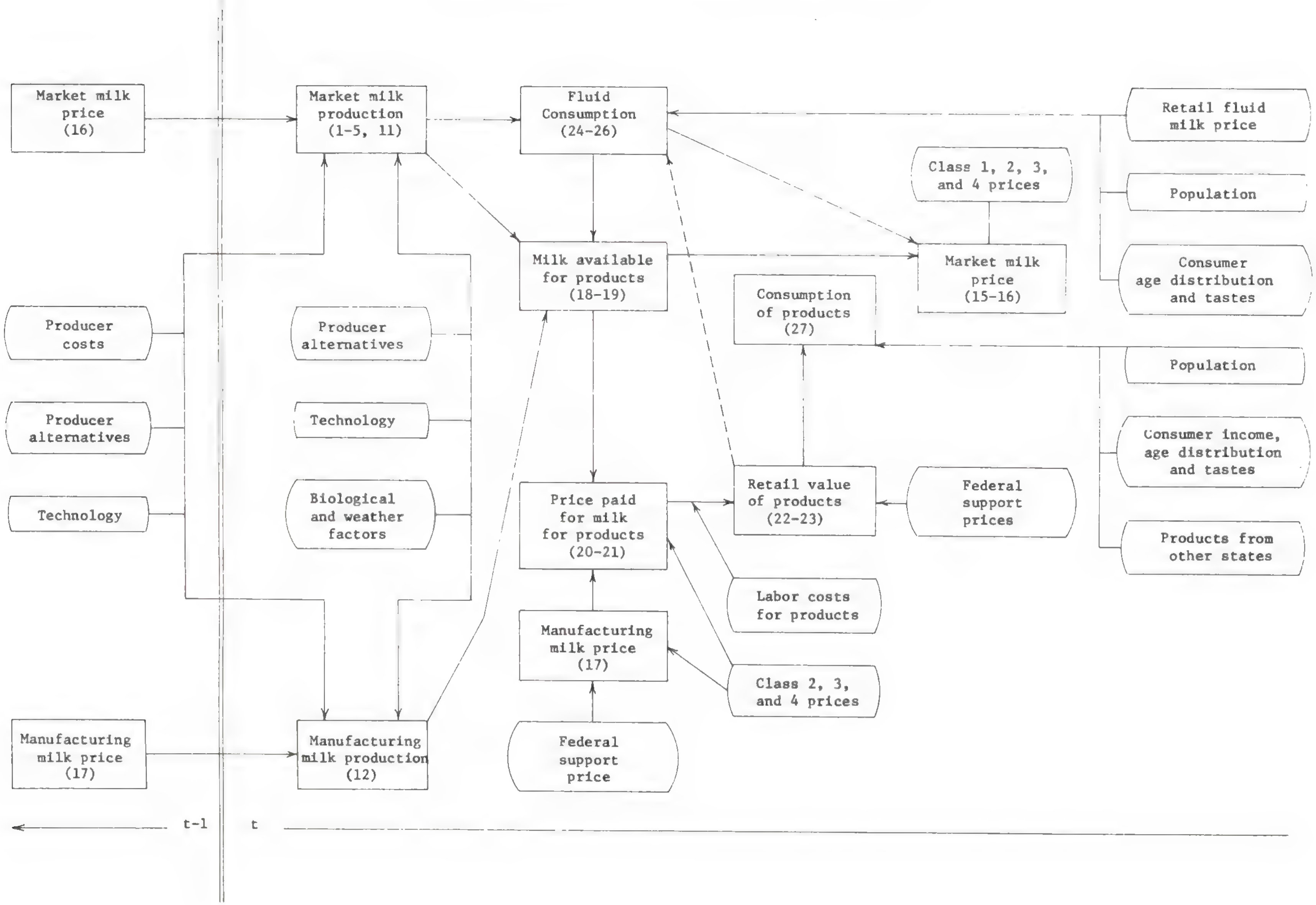
Graphical Representation

Figure 9 depicts the important relationships in the California dairy industry. For simplicity, the regional specification of market milk production and the utilization of milk as milkfat and solids-not-fat are excluded. Those variables whose values are determined primarily within the sector (endogenous variables) are indicated by rectangles, while variables whose levels are important to the industry but are determined in other sectors of the economy (exogenous variables) are represented by ovals. The numbers in parentheses in the rectangles reference the appropriate equation(s) in the structural model (Table 7) outlined later. The arrows indicate the expected direction of major influence.

[1/] The arrangement at the time consisted of handler pooling rather than statewide pooling.

FIGURE 9

A Graphical Representation of the California Dairy Industry



The lefthand section of the graph indicates those factors from previous periods that affect the current production of market and manufacturing milk. These variables include the prices of market and manufacturing milk, production costs, returns from alternative uses of resources, and technological advances. In addition, current costs and returns from alternative uses of resources affect production. Due to the time-consuming procedure used to establish the price paid to the market milk producer, the price currently received is not known prior to the end of the bimonthly time period used in this study.

The available supply of market milk is first used to satisfy the demand of fluid milk processors. The remaining market milk supply and the manufacturing milk supply are used to satisfy the demands of manufacturers of dairy products other than fluid milk.[1/] Although the manufacturing milk price is not a controlled price, its level is in line with the class 2, 3, and 4 market milk price and the Federal support price for manufacturing milk. The average market milk price is a weighted average of the established class 1-4 prices with utilization in each class as the weights.

The consumption of products depends upon the retail value (price) of these products and exogenous factors. The consumption of fluid milk is influenced by the retail price with its controlled minimum level, by numerous exogenous factors, and by the retail value of milk products; however, the dashed line for this last relationship is used to indicate that the influence may be minor.

The Structural Model

To more precisely define the relationships described above, the system outlined in Figure 9 must be given specific mathematical form.[2/] The model specified contains 27 equations; 13 of the equations are specified to measure the economic behavior of different segments of the

[1/] The exception to this simple scenario is that certain class 2 products (see previous section) must now be made from market milk.

[2/] Readers interested in results but not the quantitative procedures used to obtain these results should skip to the section on empirical estimates beginning on page 47.

industry. These 13 equations are referred to as behavioral relationships and contain unknown parameters (coefficients) to be statistically estimated. The remaining equations are identities required to complete the system.

The discussion now turns to the development of the specific form of the thirteen behavioral relationships. Following this discussion and prior to the empirical estimation in the next section is a table summarizing the structural model. This summary, Table 7 on pages 48-53, includes the variables in all 27 equations, the exact form of all identities, and the definition of all variables; the table should be a useful reference to the reader. All equation numbers in this section and the next are identical to the corresponding relationship in Table 7, with the equations in this section preceded by "A" and the equations in the estimation section preceded by "B".

Milk Production

Although considerable effort has been invested in the analysis of aggregate milk supply response, little consensus has been reached on either the factors which significantly affect milk production or the magnitude of the price elasticity. Analyses of milk production have typically used econometric analysis. Since the introduction of distributed lag models in the late 1950's,[1/] the econometric analyses have been of three types: (1) the simultaneous estimation of equations for cow numbers and production per cow, (2) single equation estimation of total production, and (3) recent attempts to estimate recursive models of the milk production sector. Table 5 provides a summary of the studies of the first two types.

Three studies employ two stage least squares to simultaneously estimate cow numbers and production per cow. Zepp and McAlexander [1969], using yearly changes for these two variables in a simplistic model, obtained prediction results that proved to be better than a

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[1/] Prior to the introduction of distributed lag models, the analysis of supply measured only short-run effects. Examples of such studies include Cochrane [1958] and Halvorson [1955].

TABLE 5

Summary of Selected Studies of U. S. Milk Production Response

Author of Study	Time Series	Dependent Variables	Predetermined Variables: Milk price	Lagged milk price	Lagged dependent variable	Roughage supply	Concentrate supply	Concentrate price	Beef price	Hog price	Production per cow	Cow numbers	Cows bred artificially	Labor cost	Elasticity SR	Elasticity LR
Halvorson [1958]	1927-57	Milk Prod.		S	S	S	I		I	I					.157	.403
Cromarty [1959]	1929-53	Milk Prod.	S			S		S				S			.212	--
Wipf & Houck [1967]	1945-64	Milk Prod.		S	S	S		S	S						.027 to .140	.041 to .192
Prato [1973]	1950-68	Cow Numbers	I		I			I	S		S			I	--	--
		Prod. Per Cow	I		S			I				I	S		--	--
Hammond [1974]	1947-72	Milk Prod.		S	S				S	S			I	S	.039	.145
Wilson & Thompson [1967]	1947-63	Cow Numbers	I	I	S			I	S		I			I	.003	.521
		Prod. Per Cow	I	I								S	S			

I - Included but not significant at 5 percent level of significance.
S - Included and significant at 5 percent level of significance.

recursive programming model. Wilson and Thompson [1967] and Prato [1973] estimate these two equations as part of simultaneous equation models of the dairy industry. The resulting inclusion of current milk prices in the structural equation indicated that the use of lagged prices may be more appropriate as this year's price never proved to be statistically significant.

Halvorson [1958], Wipf and Houck [1967], and Hammond [1974] have used the partial adjustment hypothesis on annual U. S. data to estimate total milk production (see Table 5). Wipf and Houck and Hammond found the coefficient of adjustment to be about 0.6 while Halvorson's investigation found it to be about 0.4. All three specifications included milk price lagged one year and found it to be highly significant. Each study found milk supply to be inelastic in the short and long run with Halvorson obtaining a somewhat more inelastic response. Hammond was unable to obtain significance on any cost of production variables while the other two studies had some success, particularly Wipf and Houck with significant coefficients on grain prices and roughage available. Hammond found several measures of opportunity cost--beef price, land value, the unemployment rate, and hog price--to have significant coefficients while Wipf and Houck found the beef price to be very important. As is common with time series analyses of this type, all three studies recorded impressive R^2 values. Graphic <u>ex post</u> verification of the Hammond model provided impressive results.

Two additional single-equation analyses are of particular interest for this study; Hammond [1974] estimates supply response for the Pacific region (California, Oregon, and Washington), and Chen, Courtney, and Schmitz [1972] estimate the response for California market milk using quarterly data. Both studies found price elasticities larger than in most other studies. Hammond calculated a long-run elasticity of 1.04; he also found that the adjustment in production resulting from a price change took longer in the Pacific region than in other regions.

Chen, Courtney, and Schmitz estimated quarterly supply of market milk in California using a geometric and a second order polynomial lag. Explanatory variables include a milk price/purchased feed ratio, a technology variable, and a seasonal dummy variable. The authors conclude that the polynomial lag model produced superior results; however, the price variables were only significant when the technology variable was excluded. With this exclusion a seven period lag was chosen. Prices lagged two through five periods had the greatest effect; a long-run elasticity of 2.53 was obtained. The coefficient on P_t was not significant and had a small value.[1/]

The third type of econometric estimation of milk production involves estimating recursive models of the milk producing sector based on biological as well as economic considerations. These models are based on simple accounting equations first outlined by Frick and Henry [1956]. Elterich and Johnson [1970] employ this approach to develop a recursive model of the Connecticut dairy industry using annual data from 1939-1966. Hallberg [1973a] proposes a somewhat expanded model with structural equations for cows on hand at the beginning of the year, deaths during the year, the culling rate, calves produced this year, heifer calves produced during this year, herd replacements during (t+2), heifer calf culling rate, veal calves marketed during this year, and milk output per cow. His proposal is to estimate this model for each of several regions. To illustrate the approach he estimates a model with fewer equations (due to data limitations) for the entire U. S.

Jackson [1973] estimated a recursive model for the Pacific region (California, Oregon, and Washington). A polynomial lag model was used to estimate structural equations for number of cows, yield per cow, concentrate fed per cow, number of heifers, and cull cow numbers. The estimated elasticities indicate an inelastic cow number response (0.57 in the short run [sum of years t and t-1] and 0.71 in the long run) and an inelastic yield response (0.63); however, the total supply elasticity is then slightly elastic (1.21 in the short run and 1.34 in the long run). The response in the Pacific region was more elastic than that estimated for the major milk producing areas (Lake States and the Northeast) but less elastic than many other regions particularly in the long run.

[1/] No reason was given for considering P_t as an independent variable in the single-equation framework.

Although recursive models have great potential, several significant limitations appear:

1. The accuracy of some of the data is questionable. Elterich and Johnson [1970, p. 12] comment: "The authors are apprehensive about the quality of data concerning capital stock and labor used on dairy farms."

2. There is no method of specifying separate equations for Grade A (market) and Grade B (manufacturing) producers.

3. In some areas, particularly large-scale dairy areas like California, there are sales of dairy animals between states which are not recorded.

Due to these limitations, the construction of such a model for California is not feasible in this study.

Based upon the above material, analysis of the industry, and the data and time available, the conclusion was reached to estimate several total production equations. Each equation should contain variables to reflect (1) the profitability of milk production, (2) the opportunity cost of the owners' labor and capital, (3) the gradual improvement in technology, management, and genetic ability and (4) the seasonality of milk production.

Significant differences exist between dairies producing market milk and those producing manufacturing milk, and among milk dairies in different regions of California. Mindful of the likelihood that these differences affect the supply response, six production response equations are specified: one for manufacturing milk and five for market milk with one for each of the regions outlined in Figure 2, page 8. Since the availability of data dictated that different variables be specified for market and manufacturing milk producers, they are discussed separately, with the five market milk response equations discussed first.

<u>Market Milk</u>

Profitability of production is determined by the price received, the cost of production, and the production per cow. The typical specification of profitability in the studies mentioned in the previous section was to include the milk price and the cost of one or more inputs. For this study, an alternative procedure was chosen; the procedure is to calculate the short-run margin per cow or the price minus the variable costs per hundredweight times production per cow.

This procedure was employed for two reasons. First, this value represents the return to the dairyman; any substitution of inputs due to input price changes has already occurred. For most of the previous studies, this procedure was not a viable alternative because the cost of production data were not available. The second reason is that the separate specification of prices received and costs of production gave inferior results including the frequent occurrence of incorrect signs. Although this result is surprising from a theoretical viewpoint and somewhat inconsistent with results reported in the literature (although Hammond [1974] discarded all feed cost variables), the problem may relate to State milk control procedures since these same cost of production figures are employed as a basis for determining class 1 prices. Consequently, a causation problem is created, and the ambiguous results may be the consequence.

Very little guidance is available for selecting a lag structure on margin per cow since the available literature deals predominantly with annual data and the timing of producer responses is ambiguous. Chen, Courtney and Schmitz [1972] specify a second degree polynomial lag function using quarterly observations; however, their results contain few variables and the lag is rather short (two years). Analysis of actions of dairymen indicates that they often adopt a short-run and a long-run response to alterations in the margin they are receiving. One of two short-run courses of action is commonly taken. The first is to increase (decrease) production by increased (decreased) feeding and reduced (increased) culling when returns increase (decrease). On the other hand, producers, having large fixed costs, may determine that they must generate an approximately constant income stream. Their short-run reaction to a reduced margin, consequently, is often to generate additional production by decreased culling or even adding cows to maintain the income stream. Not only are the results of the alternative courses of action conflicting, the major impact of the actions may not be felt for many months.

Although the direction of the long-run capacity decision is unambiguous, the length of time before the impact of the decision is reflected in total production varies dramatically among producers and regions. Once a decision is made to increase capacity, plans must be formulated for the expansion. Producers can spend many months choosing among the numerous milking, feeding, and housing systems. Only after additional delays for construction can expansion of the herd begin. Once again alternatives are available including purchasing mature cows, purchasing heifers, and raising replacements.

To specify the length of time required for decisions based on margins to be reflected in total production, bimonthly observations lagged up to three years were initially considered. Since these eighteen observations cannot be specified as eighteen variables, three combinations of the eighteen were investigated: (1) a second degree polynomial;[1/] (2) three averages (simple average of t-1 through t-6 denoted as m_L, simple average of t-7 through t-12 denoted as m_{L-1}, and simple average of t-13 through t-18 denoted as m_{L-2}); and (3) four bimonthly observations (t-1, t-6, t-12, and t-18). Although all three forms provided reasonable results, the six-period averages are selected because the results are more rational. The results from the polynomial lag apparently produced inferior results because the polynomial function does not approximate the form of the lagged responses of producers. The use of four bimonthly observations completely disregards the information contained in the remaining fourteen observations; consequently, inferior results are obtained. To test whether all production adjustments have been completed within three years, an additional average margin for periods t-19 through t-24 (year 4) was introduced in the ensuing analysis (m_{L-3}). In regions where many producers raise their own replacements, production adjustments may not be completed within three years due to the length of the lags described above.

[1/] See Chen, Courtney, and Schmitz [1972] for details of the form of the polynomial lag employed.

The possibility of including several margin variables without introducing overly restrictive multicolinearity is created by two factors not usually present when analyzing supply response for milk. The first is the large number of observations available with bimonthly observations. The second is the relatively small correlation between margin variables (m_L, m_{L-1}, m_{L-2}, m_{L-3}) because the margin is a combination of three variables--price, costs, and production. The correlations among the variables for the different periods of lag generally range from 0.6 to 0.8; for price variables alone the correlations are 0.95 and higher.

Although the use of several average margin variables is not a sophisticated distributed lag scheme, its use more nearly represented the lag structure of the dairyman than did the geometric or the polynomial distributed lag. Other distributed lag schemes could have been tested; however, since operational computer programs were unavailable, it was decided that the additional time required would be better spent on other aspects of the study.

Three variables were chosen to represent the opportunity cost of the owners' labor and capital: (1) the beef price, (2) the index of land prices in California, and (3) the interest rate lagged two years. The beef price is included to reflect both the price at which marginal cows can be culled and the cost of replacements since the beef price and the price of replacements are highly correlated.

Because California agriculture is so diversified, the inclusion of profitability variables for alternative enterprises was impractical. Instead, the index of California land prices was specified since land prices reflect the profitability of the best possible use of the land.[1/] Normally, land prices increase rapidly (slowly) when the price of specialty crops are high (low). When these prices are high, feed input prices are high and roughage in particular may be difficult to obtain. The effect on the cost of production is reflected in the margin variables, but the increased uncertainty associated with obtaining an adequate supply of roughage is not. The land price does, however, reflect this change in the availability of roughage.

[1/] Although many large dairies include little land, the purchase of land is an alternative use of capital.

To reflect the availability of capital and the return from investing capital in items other than dairy facilities, the interest rate is specified as the third opportunity cost variable. Because the effect of additional investment in dairy facilities is not totally reflected in production for some time, the variable is lagged two years.

Any attempt to specify behavioral relationships using time series data faces the problem of incorporating changes resulting from improvements in technology, management, and genetic ability. The selection of variables to reflect these changes is nearly impossible. In this study, as in most studies, proxy variables are specified to approximate these changes. The percentage of cows in California on DHI test is used as a proxy for management while a time trend is specified as a proxy for gradual change in technology and genetic ability.

The final set of variables is necessitated by the bimonthly time period and the seasonality of milk production. Due to genetic factors, climatic conditions, and traditional practices, more milk is produced in the spring and summer than in the fall and winter, ceteris paribus. In order to estimate the importance of seasonality the January- February period is selected as a base period, and five dummy variables are specified. The dummy variables then measure the difference between production in January-February and each of the other five bimonthly periodsdue to seasonality.

The five market milk equations are specified as follows. The sources of all variables are delineated in Appendix A:

(A.1-A.5) $$q_t^{Aj} = b_{j0} + b_{j1}m_L^{Aj} + b_{j2}m_{L-1}^{Aj} + b_{j3}m_{L-2}^{Aj} + b_{j4}m_{L-3}^{Aj} + b_{j5}p_T^{BF} + b_{j6}p_T^{L} + b_{j7}p_{T-2}^{INT} + b_{j8}dhi_T + b_{j9}TM + \sum_{i=1}^{5} b_{j,9+i}\, S_t^i + v_{jt},$$

$$j = 1, 2, \dots, 5$$

where

t = The bimonthly observation t.

T = The observation is the simple average of bimonthly observations t through t-5.

T-2 = The observation is the simple average of bimonthly observations t-12 through t-17 (two years ago).

L = The observation is the simple average of bimonthly observations t-1 through t-6.

L-i, i = 1, 2, 3 = The average value of the variable lagged 2, 3, and 4 years. Calculated by averaging bimonthly observations t-1 -(6xi) through t-6 -(6xi).

q^{Aj} = Production (hundredweight per day) of market milk in region j,

j = 1: Southern California,
2: South San Joaquin Valley,
3: North San Joaquin and Sacramento Valleys
4: Central Coast, and
5: Mountain areas and North Coast.

m^{Aj} = Margin per cow (price minus variable costs times hundredweight production in the bimonthly period) for market milk producers in region j (See Table 7, Equations 6-10 for calculation).

p^{BF} = Price per hundredweight received for beef in California.

p^{L} = Index of land prices in California.

p^{INT} = Interest rate in percent.

dhi = Percent of all dairy cattle in California on DHI test.

TM = Time trend: January-February 1961 = 1, ...

S^{i} = Dummy variables to measure seasonal effects,

i = 1: March-April
2: May-June
3: July-August
4: September-October
5: November-December

v_j = Disturbance term for region j.

These five equations give the mathematical form of the first five relationships of the model as outlined in Table 7, on pages 48-53. The next six equations (relationships 6-11, Table 7) in the structural model are identities required to link the producer subsector with the processor and consumer subsectors. An equation is required for each region to calculate the margin (m_t^{Aj}) using the average price received for market milk (p_t^A) determined in the processor subsector and exogenous variables. The sixth identity simply calculates total market milk production by summing the regional productions.

Manufacturing Milk

Since less than ten percent of California milk production occurs on manufacturing milk dairies and since manufacturing milk dairies are more homogeneous than market milk dairies, one equation for California manufacturing milk production is specified. Unfortunately, the margin per cow variables cannot be used in this equation as cost of production data are no longer collected for manufacturing milk dairies. The alternative specification for profitability is to use lagged milk price received and the price of corn. Corn is the major purchased feed input on these dairies. The same variables are used for the other factors affecting milk production.

The following equation is specified for manufacturing milk:

$$(A.12)\quad q_t^B = b_{60} + b_{61}p_L^B + b_{62}p_{L-1}^B + b_{63}p_{L-2}^B + b_{64}p_T^{CORN} + b_{65}p_T^L + \sum_{i=1}^{5} b_{6,5+i}S_t^i + v_{6t}$$

where p^B = Price received by manufacturing milk producers.

p^{CORN} = Price per hundredweight for corn.

All other variables are defined in equations A.1 - A.5.

Percent Milkfat and Solids-not-Fat

In order to determine the quantities of milkfat and solids-not-fat available to the processor subsector, total production and percent milkfat and solids-not-fat are required. The percentage fat varies seasonally and has been declining over time due to greater efforts to genetically increase milk production potential. Using a time trend as a proxy variable captures this decline very well. The following equation is specified to measure these factors:

$$\text{(A.13)} \quad PCF_t = b_{70} + b_{71}TM + \sum_{i=1}^{5} b_{7,1+i} S_t^i + v_{7t}$$

PCF_t is the percent fat and the other variables have been previously defined. Since only very recent data are available on percent solids and since percent fat and solids are very closely correlated, the percent solids is related to percent milkfat by an identity. This identity is included as the fourteenth equation in the model; see Table 7, pages 48-53.

Processor Prices and Allocation to Final Products

Numerous price and allocation functions are carried out in the processor subsector. These functions are divided into the following three types of decisions: (1) the prices processors pay market and manufacturing milk producers (Table 7, relationships 15-17), (2) the allocation of milkfat and solids-not-fat to fluid and manufacturing uses (relationships 18 and 19), and (3) the prices charged consumers for dairy products (relationships 20-23).[1/] Because of the high degree of governmental control exerted in the California dairy industry, many of the market functions performed in this subsector are represented by a control variable or by an identity.

Because the focus of the study is at the farm level and because accurate data for individual manufactured dairy products are difficult to obtain, the consumer and processor subsectors are specified for fat and solids-not-fat used in fluid and manufactured products rather than by individual dairy products. This specification is consistent with recent models by Wilson and Thompson [1967] and Prato [1973].

[1/] As was noted in the section outlining the structure model, several of these relationships are determined simultaneously with consumer demand.

Prices Paid Producers

The average price paid to market milk producers is determined by an identity. This equation (Table 7, equation 15) weights the price paid for milkfat and solids-not-fat in fluid and manufactured products by the quantities of fat and solids used for each purpose.[1/]

The price paid manufacturing producers is not a control variable; however, the price is closely related to the price paid market milk producers for milk used in manufactured dairy products and to the Federal support price for manufacturing milk. These relationships are expressed as follows:

$$(A.17) \quad P_t^B = b_{80} + b_{81}SP_t + b_{82}PMP_t + b_{83}TM + \sum_{i=1}^{5} b_{8,3+i}S_t^i + v_{8t}$$

where SP = Federal support price for manufacturing milk.

PMP = Hundredweight equivalent of average price paid by manufacturing dairy product processors for market milk fat (PFP) and market milk solids (PSP)[2/]

Again, the other variables have been defined previously and all data sources are referenced in Appendix A.

Allocation to Final Usage

Since fluid usage returns the most income to the industry and represents the most perishable products, all demands for fluid products are filled first, with the residual available for manufactured dairy products. Although this scenario might be somewhat simplistic, it is an adequate representation of reality. Given production (from the producer subsector of the model) and consumption of fluid products (from the consumer subsector), the allocation equations in the model

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[1/] The complications introduced by quota and base (see discussion in the first section) can be overlooked since an average price is being calculated.

[2/] Assumes milk is 3.5 percent fat and 8.7 percent solids. Manufacturing milk is not component priced.

are simply accounting identities. Relationships 18 and 19 in the structural model (see Table 7, pages 48-53) are identities to calculate the amount of fat and solids produced in California that are available for processing into manufactured dairy products. The identity for milkfat (18) simply subtracts the fat used in fluid products (which is determined in the consumer subsector) from the total fat produced in California. The solids identity (19) is somewhat more complicated since the actual amount of solids used in fluid products is unavailable. The quantity is estimated by increasing the average solids content of all milk by ten percent. The increase is required to include solids used to fortify fluid milk.

Retail Prices

Three retail prices are required by the model: the retail price for a half gallon of fluid milk, the retail value of milkfat sold in manufactured dairy products, and the retail value of solids-not-fat sold in manufactured dairy products. During the time period of the observations for this study, the retail fluid milk price was established by the Bureau of Milk Stabilization.[1/] The calculation of the data series for retail value of fats and solids is based on retail price of manufactured dairy products and the composition of the products; the details are in Appendix A.

Behavioral equations are specified for the retail value of fats and solids that reflect the interactions between processors and consumers. These marketing margin equations include the price paid for fats and solids and variables that influence the magnitude of the marketing margin. Since fats and solids for products come from both market and manufacturing milk, the average price paid for fats and solids produced in California and used for processing in manufactured dairy products must be calculated. These identities (Table 7, relationships 20 and 21) weight the prices paid market and manufacturing milk producers by the quantities used.

[1/] Although the Bureau actually establishes minimum prices, the price they set has almost always been the effective price.

Several factors are hypothesized to affect the retail value of fat (RFP^m) in addition to the price paid for fat (APF). The price paid for solids (APS) is introduced to reflect the complementarity between fats and solids. The hourly wage rate for manufacturing dairy products in California (XMCH) is included to represent the cost of production since labor is the largest processing cost. In recent times an increasing proportion of the fat has been allocated to cheese production. Since cheese production involves a larger marketing margin than most dairy products, the proportion of fat used in manufactured dairy products that is used in cheese (CHESF) is hypothesized to affect the retail fat value. To reflect the impact of CCC purchases on retail prices, the support price for butter (SB) is included. A time trend is included as a proxy for the _ceteris paribus_ decline in margin due to technological innovations and economies of size.

The resulting specification of the behavioral equation for retail value of milkfat used in manufactured dairy products is:

$$\text{(A.22)} \quad RFP^m_t = b_{90} + b_{91}APF_t + b_{92}APS_t + b_{93}SB_t + b_{94}XMCH_t + b_{95}\, CHESF_t + b_{96}TM + \sum_{i=1}^{5} b_{9,6+i}\, S^i_t + v_{9t}$$

A somewhat analogous equation is specified for the retail value of solids sold in manufactured dairy products (RSP^m). The wage rate, the proportion of solids used in cheese (CHESS), and time trend are specified for similar reasons. No variable is included to reflect CCC purchases because surplus supplies of solids have been less frequent.

The resulting specification of the behavioral equation for retail value of solids-not-fat used in manufactured dairy products is:

$$\text{(A.23)} \quad RSP^m_t = b_{10,0} + b_{10,1}APS_t + b_{10,2}XMCH_t + b_{10,3}CHESS_t + b_{10,4}TM + \sum_{i=1}^{5} b_{10,4+i}\, S^i_t + v_{10t}$$

These two relationships complete the specification of the processor subsector of the structural model (see Table 7, relationships 15-23).

Demand for Dairy Products

Demand equations for three types of dairy products are specified: per capita consumption of fluid milkfat, per capita consumption of fluid skim milk, and per capita consumption of milkfat and solids-not-fat in manufactured dairy products. The theory of the consumer behavior of individuals is well developed and documented elsewhere (George and King [1971], Henderson and Quandt [1971]). This theory is used to justify inclusion in demand equations of price of the product (referred to as own price), the price of substitutes, and income.[1/] Other variables representing demographic and other characteristics that change over time must be specified for aggregate, time-series analysis.

Table 6 summarizes own price and income elasticities from several of the more comprehensive studies of the demand for dairy products. Most studies have concluded that the demand for dairy products, like that for most food items, is both price and income inelastic. Most of the research in this area has been with fluid products; the resulting price elasticities have generally been in the range of -0.2 to -0.6, with income elasticities in the range of 0.0 to 0.5. The recent work by Boehm and Babb [1975] using data from the Market Research Corporation of America National Consumer Panel found the demand for fluid products to be very income inelastic but price elastic. Using cross section data they obtained price elasticities that ranged from -0.833 for one percent milk to -1.701 for regular whole milk. Using the same data they estimated a time series model in which the price elasticities ranged from -0.12 to -1.18 with total fluid milk -0.14. They argue that the inelastic results from the time series model give the short-run response, and the elastic response from the cross section is the long-run result.

[1/] The basic assumption is that consumers maximize utility subject to their budget constraint. The resulting Lagrangian function is then solved to get: $g_j = g_j(p_1, p_2, \ldots, p_n, Y), j=1, \ldots, n$ where n is the number of commodities. The concept of want independence (see Frisch [1959]) is used to eliminate equations for non-dairy products and price variables with small cross-elasticities.

TABLE 6

Price and Income Elasticities for Dairy Products

Author	Elasticity[a/] Price	Income	Type of Study
		A. Fluid Milk	
Brandow [1961]	-0.285+	0.16+	All food elasticities
George & King [1971]	-0.346+	0.204+	All food elasticities
Prato [1971]	-5.765*	--	334 Florida households
Boehm & Babb [1975]	-1.628*	0.052	Market Research Corporation of America Data - cross section
		B. Frozen Dairy Products	
Brandow [1961]	-0.55+	0.35+	All food elasticities
George & King [1971]	-0.528+	0.331+	All food elasticities
Boehm & Babb [1975b]	-0.471*	0.07	MRCA - cross section
		C. Cottage Cheese	
Boehm & Babb [1975b]	-1.29*	0.168*	MRCA - cross section
		D. Cheese	
Brandow [1961]	-0.7+	0.45	All food elasticities
George & King [1971]	-0.46	-0.25	All food elasticities
Boehm & Babb [1975a]	-0.851*	0.234*	MRCA - cross section
		E. Butter	
Brandow [1961]	-0.85+	0.33+	All food elasticities
George & King [1971]	-0.65+	0.32+	All food elasticities
Boehm & Babb [1975a]	-0.76*	0.17	MRCA - cross section
		F. Nonfat Dry Milk	
Boehm & Babb [1975b]	-2.24	-0.03	MRCA - cross section

[a/] An asterisk (*) indicates that the elasticities were found to be significant at the 5 percent level of significance; a (+) indicates no test of significance was possible or was performed.

Most authors have concluded that the demand for most manufactured dairy products is more price and income elastic than the demand for fluid milk. The results reported by Boehm and Babb support the conclusion that the products are more income elastic, but their results did not support the conclusion that fluid products are more price inelastic.[1/] They obtained an inelastic price response for most perishable dairy products including all types of frozen dairy products, dairy dips, and yogurt. The demand for cottage cheese, half & half cream, and sour cream, although price elastic, was less elastic than the demand for fluid products.

As might be expected, there was considerable variation in price elasticity of the storable dairy products; nonfat dry milk powder exhibited an elastic response (-2.24), butter was inelastic, and the cheese products investigated fluctuated around an elasticity of -1.0. Boehm and Babb found the meat price index to have a significant effect on cheese consumption. Similarly, butter and margarine produced a significant positive cross-elasticity.

Demand for Fluid Milkfat and Fluid Skim

Although it is expected that these two equations will contain the same or similar variables, it is hypothesized that the coefficients derived in the two separate equations will be useful in projecting future changes in the composition of fluid purchases. The per capita consumption of fluid milkfat has been declining more rapidly than per capita consumption of fluid skim. The projection of a continuation or alteration in this trend can be used to more accurately calculate the fat and solids remaining for processing into products.

The variable specification is identical for the two equations. Two price variables are included--the retail price of fluid milk (RFLP) and the retail value of solids sold in manufactured dairy products (RSP^m).[2/]

[1/] These conclusions are reached from the results in Table 6 and from further analysis of the three publications authored by Boehm and Babb [1975, 1975a, 1975b].

[2/] The data sources and transformations for all variables are described in Appendix A.

The latter is included to reflect the substitutability among dairy products particularly fluid milk and evaporated milk products. To reflect the large milk consumption by children, an age distribution variable, the proportion of the California population attending kindergarten through the eighth grade (AD), is included. A time trend is specified as a proxy for the continuing change in consumer tastes from milk to other beverages. The per capita consumption of imitation dairy products in California (XIMIT) is specified to reflect (1) the substitutability between fluid and imitation milk and (2) the reluctance of consumers to purchase milk during periods of increased cholesterol concern. Income was not specified in the equation due to low significance and severe multicolinearity with milk price, value of solids, and the time trend.

The resulting specification of the behavioral equations for fluid milkfat and fluid skim demand is:

$$\text{(A.24)} \quad RFQF_t = b_{11,0} + b_{11,1}RFLP_t + b_{11,2}RSP^m_t + b_{11,3}AD_t + b_{11,4}XIMIT_t + b_{11,5}TM + \sum_{i=1}^{5} b_{11,5+i}S^i_t + v_{11t}$$

where $RFQF_t$ = Per capita consumption of milkfat in fluid (Class 1) products.

$$\text{(A.25)} \quad RSQF_t = b_{12,0} + b_{12,1}RFLP_t + b_{12,2}RSP^m_t + b_{12,3}AD_t + b_{12,4}XIMIT_t + b_{12,5}TM + \sum_{i=1}^{5} b_{12,5+i}S^i_t + v_{12t}$$

where $RSQF_t$ = Per capita consumption of fluid skim milk.

An identity (Table 7, relationship 26) is then included to calculate per capita consumption of fluid milk ($RFLQ_t$) by summing $RFQF_t$ and $RSQF_t$.

Demand for Milkfat and Solids-not-Fat in Products

The preferred specification of separate equations for milkfat and solids-not-fat sold in manufactured dairy products proved to be impossible because of the prevailing pricing policy of the Bureau of Milk Stabilization to increase the value of solids relative to fat. Although this policy has a sound economic basis, the procedure of making large adjustments of the controlled prices every year or two with no relative change in between did not adequately match the gradual but continuous economic adjustment in uncontrolled prices.

The specified equation contains mostly economic variables; the demand for each manufactured dairy product is affected by a different set of demographic variables, but few demographic variables exert a large impact on demand for all manufactured dairy products.[1/] The economic variables included are the two own price variables (retail value of fat (RFP^m) and solids (RSP^m) in products), the retail price of fluid milk (RFLP), and per capita personal income (Y). The fluid milk price reflects the above-mentioned substitutability between fluid and evaporated milk. In addition the dummy variables for seasonality and a time trend as a proxy for taste changes are included.

The resulting behavioral equation for demand for fats and solids sold in manufactured dairy products is:

$$(A.27)\quad RMDQ_t = b_{13,0} + b_{13,1}RFP^m_t + b_{13,2}RSP^m_t + b_{13,3}RFLP_t + b_{13,4}Y_t + b_{13,5}TM + \sum_{i=1}^{5} b_{13,5+i}S^i_t + v_{13t}$$

[1/]The specification of an equation for each of the manufactured dairy products would be better for this section of the model; however, since the emphasis in this study is on the California dairy industry and fluid products, the use of one equation was deemed to be satisfactory. The multiple equation specification would be difficult but useful and should reflect a national demand since a national market exists for products. Rojko [1969] discusses such a specification.

Summary of the Structural Model

As indicated in the previous sections, Table 7 (pages 48-53) contains the 27 relationships and all variable definitions for the structural model of the California dairy industry. Twenty-seven endogenous variables (variables whose value is determined within the system) and 42 exogenous variables (variables whose values are determined outside of the system) are included in these relationships; six of the 42 exogenous variables are control variables whose values are established by the Federal "Dairy Price Support Program" or by the California Bureau of Milk Stabilization.

Equations 1-5, 12, 13, 17, 22-25, and 27 are behavioral equations to be estimated. Equations 1-12 of Table 7 determine the supply of milk available. These equations are considered independent of demand because current price received is not included as an explanatory variable.

In the processor and consumer subsectors relationships 18, 19, 20, 21, 23, 24, 25, and 26 form a simultaneous subsystem for the consumption of fluid milk products, the retail value of solids in products, and the quantities available and average price paid for fat and solids produced in California and used in manufactured dairy products. The simultaneity of this system results from the substitutability of solids in dairy products and fluid milk.

Equations 17, 22, and 27 are a part of the processor and consumer subsectors but are not included in the simultaneous subsystem. The next section contains the empirical estimates of the behavioral equations developed in this section.

EMPIRICAL ESTIMATES OF BEHAVIORAL RELATIONSHIPS

Estimates of the parameters of the behavioral equations described in the previous section are derived from bimonthly (six per year) observations for the period 1958 through 1973. As indicated earlier, the bimonthly time period is chosen to be consistent with the time frame

TABLE 7

A Reader's Guide to the Structural Model of the California Dairy Industry

Relationship for[a/] and Variables Included[b/] (exogenous variables in parentheses)

Producer Subsector[c/]

1-5. Daily market milk production in region j: q_t^{Aj}, m_L^{Aj}, m_{L-1}^{Aj}, m_{L-2}^{Aj}, m_{L-3}^{Aj}, (P_{T-2}^{INT}), (P_T^{BF}), (P_T^L), (dhi_T), (TM), (s_t^1), (s_t^2), (s_t^3), (s_t^4), (s_t^5), (v_{jt})

6-10. where: $m_t^{Aj} = [p_t^A - (L_t^j) - (vc_t^{Aj})] \times (PPC_t^j)$

11. Market milk production: $q_t^A = q_t^{A1} + q_t^{A2} + q_t^{A3} + q_t^{A4} + q_t^{A5}$

12. Daily manufacturing milk production: q_t^B, p_L^B, p_{L-1}^B, p_{L-2}^B, (p_T^{CORN}), (p_T^L), (s_t^1), (s_t^2), (s_t^3), (s_t^4), (s_t^5), (v_{6t})

13. Percent milkfat: PCF_t, (TM), (s_t^1), (s_t^2), (s_t^3), (s_t^4), (s_t^5), (v_{7t})

14. Percent solids: $PCS_t = 7.07 + .444 \times PCF_t$

15. Average price per cwt. of market milk paid by processors: $pp_t^A =$

$$\{RFQF_t \times (C1FP_t) + .01 \times RSQF_t \times (C1SP_t) + [(PFQ_t^m - .01 \times PCF_t \times q_t^B/(POP_t)] \times (PFP_t) + [(PSQ_t^m - .01 \times PCS_t \times q_t^B/(POP_t)] \times (PSP_t)\}/\{[q_t^A/(POP_t)]/100\}$$

16. Average price per cwt. of market milk received by producers:

$$p_t^A = pp_t^A - (H_t)$$

TABLE 7 (continued)

Processor Subsector[d/]

17. Manufacturing milk price: p_t^B, (SP_t), (PMP_t), (TM), (s_t^1), (s_t^2), (s_t^3),

(s_t^4), (s_t^5), (v_{8t})

18. Fat produced in California and available for products: PFQ_t^m =

$$[(PCF_t/100) \times (q_t^A + q_t^B)] - (RFQF_t \times (POP_t))$$

19. Solids produced in California and available for products: PSQ_t^m =

$$[(PCS_t/100) \times (q_t^A + q_t^B)] - [(PCS_t \times .011) \times (RFLQ_t \times (POP_t))]$$

20. Average price paid for fat produced in California for products:

$$APF_t = \{(PFP_t) \times PCF_t \times [q_t^A - (RFQF_t \times (POP_t))] + \{[(PFP_t) \times PCF_t/((PFP_t) \times PCF_t + (PSP_t) \times PCS_t)]/PCF_t\} \times p_t^B \times q_t^B \times (PCS_t/100)\}/PFQ_t^m$$

21. Average price paid for solids produced in California for products:

$$APS_t = \{(PSP_t) \times [(q_t^A - (RFLQ_t \times 1.1 \times (POP_t))) \times (PCS_t/100)] + \{[(PSP_t) \times PCS_t/((PFP_t) + PCF_t + (PSP_t) \times PCS_t)]/PCS_t\} \times p_t^B \times q_t^B \times (PCS_t/100)\}/PSQ_t^m$$

22. Retail value of fat in products: RFP_t^m, APF_t, APS_t, (SB_t), $(XMCH_t)$,

$(CHESF_t)$, (TM), (s_t^1), (s_t^2), (s_t^3), (s_t^4), (s_t^5), (v_{9t})

23. Retail value of solids in products: RSP^m_t, APS_t, $(XMCH_t)$, $(CHESS_t)$,

(T), (S^1_t), (S^2_t), (S^3_t), (S^4_t), (S^5_t), (v_{10t})

Consumer Subsector

24. Per capita consumption of fluid milkfat: $RFQF_t$, $(RFLP_t)$, RSP^m_t, (AD_t),

$(XIMIT_t)$, (TM), (S^1_t), (S^2_t), (S^3_t), (S^4_t), (S^5_t), (v_{11t})

25. Per capita consumption of fluid skim milk: $RSQF_t$, $(RFLP_t)$, RSP^m_t,

(AD_t), $(XIMIT_t)$, (TM), (S^1_t), (S^2_t), (S^3_t), (S^4_t), (S^5_t), (v_{12t})

26. Per capita consumption of fluid milk: $RFLQ_t = RFQF_t + RSQF_t$

27. Per capita consumption of fat and solids in products: $RMDQ_t$, RFP^m_t,

RSP^m_t, $(RFLP_t)$, (Y_t), (TM), (S^1_t), (S^2_t), (S^3_t), (S^4_t), (S^5_t), (v_{13t})

Variable Identification[e/]

Control Variables:[f/]

C1FP = Class 1 price for fat (pound)

C1SP = Class 1 price for skim milk (cwt.)

PFP = Average price paid by manufactured dairy product processors for market milk fat

PSP = Average price paid by manufactured dairy product processors for market milk solids

PMP = Hundredweight equivalent of PFP and PSP

RFLP = Retail price for fluid milk[g/]

TABLE 7 (continued)

Endogenous Variables:

q^{Aj} = Production (hundredweight per day) of market milk in region j,

j = 1: Southern California
2: South San Joaquin Valley
3: North San Joaquin and Sacramento Valleys
4: Central Coast
5: Mountain Areas and North Coast

q^{A} = Total production of market milk

q^{B} = Total production of manufacturing milk

PCF = Percent fat in milk produced in California

PCS = Percent solids in milk produced in California

p^{B} = Manufacturing milk price

RFP^{m} = Retail value of fat in manufactured dairy products (referred to as "products")

RSP^{m} = Retail value of solids in manufactured dairy products

PFQ^{m} = Quantity of fat produced in California and used in products

PSQ^{m} = Quantity of solids produced in California and used in products

APF = Average price paid for fat produced in California and used in products

APS = Average price paid for solids produced in California and used in products

pp^{A} = Average price per hundredweight of market milk paid by processors

p^{A} = Average price per hundredweight of market milk received by producers

m^{Aj} = Margin per cow for market milk producers in region j

RFQF = Per capita consumption of milkfat in fluid (Class 1) products

RSQF = Per capita consumption of fluid skim milk

RFLQ = Per capita consumption of fluid milk

RMDQ = Per capita consumption of fat and solids in manufactured dairy products

Exogenous Variables:

p^{L} = Index of land prices in California

p^{BF} = Price per hundredweight received for beef in California

TM = Time trend: January-February 1961 = 1, ...

TABLE 7 (continued)

Exogenous Variables: continued

S^i = Dummy variables to measure seasonal effects,

i = 1: March - April
2: May - June
3: July - August
4: September - October
5: November - December

p^{INT} = Interest rate in percent

dhi = Percent of all cattle in California on DHI test

p^{CORN} = Price received for corn in California

SP = Federal support price for manufacturing milk

SB = Support price for butter

XMCH = Hourly wage rate for manufacturing dairy products in California

CHESF = Proportion of fat consumed as cheese

CHESS = Proportion of solids consumed as cheese

POP = Population of California

H = Differential between price processor pays and producer receives

L^j = Differential between average market milk price and market milk price in region j

vc^{Aj} = Variable costs per hundredweight in region j: $sct^{1j} + sct^{2j} + sct^{3j}$

PPC^j = Hundredweight production per cow in the period in region j

AD = Proportion of the population attending kindergarten through the eighth grade

XIMIT = Per capita consumption of imitation dairy products in California

Y = Personal income per capita (U.S.)

TABLE 7 (continued)

Footnotes:

a/ The equation numbers in this table correspond with the equation numbers used in the text.

b/ The subscripts have the following meaning:

$t-i$ = the $t-i^{th}$ bimonthly period

$T-I$ = the six bimonthly periods starting with the period I years ago and going back five more periods: simple average

$L-I$ = the six bimonthly periods starting with the period I years ago last period: simple average.

c/ See Figure 2 for the location of the regions.

d/ The quantities produced per day as determined from the equations in the producer subsector must be multiplied by the days in the period and by 100 to convert hundredweights to pounds prior to performing the calculations required in the processor subsector.

e/ A more complete description of the data including sources and transformations is contained in Appendix A.

f/ The control variables are in parentheses with the exogenous variables in the equations.

g/ As indicated previously, the State's authority to set minimum wholesale and retail prices on fluid milk products was repealed, effective January 1, 1978. The retail price of fluid milk was controlled during the period from which observations were drawn and, hence, is appropriately treated as an exogenous (control) variable.

normally considered by the Bureau of Milk Stabilization. The observations for 1958 through 1960 are used only for lagged variables. As described in the previous section, the system to be estimated has equations containing variables that are determined simultaneously and other equations with no simultaneously determined variables. The simultaneous equations are estimated with two stage least squares, and the remaining estimates are obtained from ordinary and generalized least squares.

Milk Production

Because the initial regression results indicated that the data are characterized by autocorrelated residuals, the six production response equations are estimated by generalized least squares.[1/] In the following three sections the results are presented, discussed, and elasticities are calculated and compared to other studies.

[1/] The presence of autocorrelation as indicated by Durbin-Watson statistics in the range of 0.6 to 0.8 is not unexpected with bimonthly data. Both first order and second order transformations were tested with the first order transformation recording superior results.

Accordingly, the two-step generalized least squares procedure suggested by Theil [1971, p. 254] is used for all results reported in this section. The first step consists of running ordinary least squares and employing the residuals to generate an estimate of the first-order autoregressive coefficient (ρ) using

$$\hat{\rho} = \frac{\sum_{t=1}^{n-1} e_t \times e_{t+1}}{(n-1)\, s^2}$$

The second stage then consists of obtaining ordinary least squares estimates from the transformed model:

$$y_t - \hat{\rho} y_{t-1} = \sum_{h=1}^{k} B_h \, (X_{th} - \hat{\rho} X_{t-1}, h) + (e_t - \hat{\rho} e_{t-1})$$

for $t=2,\ldots,n$. Because of the use of $\hat{\rho}$, only large-scale statistical properties have been derived for the resulting estimates (see Theil [1971], pp. 405-415). The results have the desirable statistical properties (e.g., consistency, efficiency, etc.) only when no lagged dependent variables are specified. Since only large-sample properties apply, a standard normal table is used for all tests of statistical significance. For more details see Theil [1971], Goldberger [1964], or Milligan [1975a].

The Results

The estimated effects of the variables specified in relationships 1-5 and 12 (Table 7) are presented below. In some regions one or more of the variables were not found to be significant and the corresponding b_{kj} is assumed to be zero. The t-statistic for each coefficient is in parentheses, the asterisks indicate the level of significance (one is ten percent, two is five percent and three is one percent), $\bar{R}^2$ is the adjusted coefficient of determination, and D-W is the Durbin-Watson statistic. For ease of comparison, the coefficients of each equation for all variables except the seasonal dummy variables are summarized in Table 8.

Southern California

$$\text{(B.1)}\quad q_t^{A1} = \underset{(8.82)***}{101076.38} - \underset{(-0.64)}{45.18}\, m_{L-1}^{A1} + \underset{(3.74)***}{226.69}\, m_{L-2}^{A1} - \underset{(-0.93)}{115.20}\, p_T^{BF} - \underset{(-2.50)**}{356.95}\, p_T^{L}$$

$$+ \underset{(4.57)***}{386.97}\, TM + \underset{(7.41)***}{2693.68}\, S_t^1 + \underset{(7.61)***}{3372.01}\, S_t^2 + \underset{(1.33)*}{616.84}\, S_t^3 + \underset{(0.87)}{388.78}\, S_t^4$$

$$- \underset{(-1.99)**}{743.76}\, S_t^5$$

$\bar{R}^2$ = .820, D-W = 1.31[1/], $\hat{\rho}$ = .53

Southern San Joaquin Valley[2/]

$$\text{(B.2)}\quad q_t^{A2} = \underset{(3.33)***}{53687.4} + \underset{(1.08)}{75.17}\, m_{L-1}^{A2} + \underset{(1.64)*}{103.37}\, m_{L-2}^{A2} + \underset{(1.92)**}{126.66}\, m_{L-3}^{A2} - \underset{(-1.34)}{640.65}\, p_{T-2}^{INT}$$

$$- \underset{(-4.05)***}{578.53}\, p_T^{L} + \underset{(1.74)**}{532.59}\, dhi_T + \underset{(5.26)***}{634.45}\, TM + \underset{(8.16)***}{2722.81}\, S_t^1 + \underset{(12.82)***}{5152.50}\, S_t^2$$

$$+ \underset{(12.83)***}{5380.47}\, S_t^3 + \underset{(8.55)***}{3439.86}\, S_t^4 + \underset{(0.80)}{267.29}\, S_t^5$$

$\bar{R}^2$ = .966, D-W = 1.29[3/], $\hat{\rho}$ = .50

[1/] At the 1 percent level of significance, this value is in the indeterminancy region.

[2/] Observations from January-February 1962 through November-December 1973 (n=72) are used in the Southern San Joaquin Valley, Northern San Joaquin and Sacramento Valleys, and the Mountain Areas and North Coast regions where m_{L-3}^{Aj} significantly affected production.

[3/] At the 1 percent level of significance, this value is in the indeterminancy region.

TABLE 8

A Comparison of the Results for Selected Variables for the Five Regional Market Milk Equations and the Statewide Manufacturing Milk Equation[a/]

Dependent Variable	Constant	m^{Aj}_{L}	m^{Aj}_{L-1}	m^{Aj}_{L-2}	m^{Aj}_{L-3}	p^{INT}_{T-2}	p^{BF}_{T}	p^{L}_{T}	dhi_{T}	TM
(B.1) q^{A1}_{t}	101076		-45.18	226.69			-115.20	-356.95		386.97
	(8.82)		(-0.64)	(3.74)			(-0.93)	(-2.50)		(4.57)
(B.2) q^{A2}_{t}	53687		75.17	103.37	126.66	-640.65		-578.53	532.59	634.45
	(3.33)		(1.08)	(1.64)	(1.92)	(-1.34)		(-4.05)	(1.74)	(5.26)
(B.3) q^{A3}_{t}	7651	-64.41	-121.78	295.46	238.58				759.35	142.00
	(0.59)	(-0.68)	(-1.18)	(2.66)	(2.17)				(1.95)	(1.22)
(B.4) q^{A4}_{t}	28603	-54.12					-222.66		73.38	65.81
	(5.98)	(-1.91)					(-5.04)		(0.54)	(2.07)
(B.5) q^{A5}_{t}	2530	18.98		12.10	18.81	-100.86	-50.90		23.84	
	(6.77)	(2.25)		(1.47)	(2.21)	(-1.95)	(-4.04)		(2.07)	
		p^{B}_{L}	p^{B}_{L-1}	p^{B}_{L-2}	p^{CORN}_{T}					
(B.12) q^{B}_{t}	73020	9416	10581	6533	-2598			-1465		
	(16.68)	(3.20)	(3.43)	(2.24)	(-1.86)			(-14.06)		

[a/] The dummy variables for seasonality are not included in this table.

Northern San Joaquin and Sacramento Valleys

$$\text{(B.3)} \quad q_t^{A3} = \underset{(0.59)}{7650.59} - \underset{(-0.68)}{64.41\, m_L^{A3}} - \underset{(-1.18)}{121.78\, m_{L-1}^{A3}} + \underset{(2.66)^{***}}{295.46\, m_{L-2}^{A3}} + \underset{(2.17)^{**}}{238.58\, m_{L-3}^{A3}}$$

$$+ \underset{(1.95)^{**}}{759.35\, dhi_T} + \underset{(1.22)}{142.00\, TM} + \underset{(8.88)^{***}}{3684.80\, S_t^1} + \underset{(13.17)^{***}}{6595.36\, S_t^2}$$

$$+ \underset{(11.63)^{***}}{6081.70\, S_t^3} + \underset{(6.16)^{***}}{3088.82\, S_t^4} - \underset{(-0.38)}{159.18\, S_t^5}$$

$\bar{R}^2 = .930$, D-W = 1.10[1/], $\hat{\rho} = .51$

Central Coast

$$\text{(B.4)} \quad q_t^{A4} = \underset{(5.98)^{***}}{28603.2} - \underset{(-1.91)^{**}}{54.12\, m_L^{A4}} - \underset{(-5.04)^{***}}{222.66\, p_T^{BF}} + \underset{(0.54)}{73.38\, dhi_T} + \underset{(2.07)^{**}}{65.81\, TM}$$

$$+ \underset{(12.11)^{***}}{1519.32\, S_t^1} + \underset{(10.41)^{***}}{1618.61\, S_t^2} + \underset{(6.65)^{***}}{1091.56\, S_t^3} + \underset{(2.62)^{***}}{410.15\, S_t^4} - \underset{(-1.16)}{149.68\, S_t^5}$$

$\bar{R}^2 = .765$, D-W = 1.21[2/], $\hat{\rho} = .62$

Mountain Areas and North Coast

$$\text{(B.5)} \quad q_t^{A5} = \underset{(6.77)^{***}}{2530.39} + \underset{(2.25)^{**}}{18.98\, m_L^{A5}} + \underset{(1.47)^{*}}{12.10\, m_{L-2}^{A5}} + \underset{(2.21)^{**}}{18.81\, m_{L-3}^{A5}} - \underset{(-1.95)^{**}}{100.86\, p_{T-2}^{INT}}$$

$$- \underset{(-4.04)^{***}}{50.90\, p_T^{BF}} + \underset{(2.07)^{**}}{23.84\, dhi_T} + \underset{(15.32)^{***}}{515.73\, S_t^1} + \underset{(21.40)^{***}}{875.23\, S_t^2} + \underset{(15.00)^{***}}{641.78\, S_t^3}$$

$$+ \underset{(7.41)^{***}}{303.47\, S_t^4} + \underset{(1.59)^{*}}{53.96\, S_t^5}$$

$\bar{R}^2 = .882$, D-W = 1.20[2/], $\hat{\rho} = .54$

[1/] The hypothesis of positive autocorrelation is accepted at the 1 percent level of significance.

[2/] At the 1 percent level of significance, this value is in the indeterminancy region.

Manufacturing Milk

$$\text{(B.12)}\quad q_t^B = \underset{(16.68)^{***}}{73020.2} + \underset{(3.20)^{***}}{9415.54}\, p_L^B + \underset{(3.43)^{***}}{10581.1}\, p_{L-1}^B + \underset{(2.24)^{**}}{6533.04}\, p_{L-2}^B$$

$$- \underset{(-1.86)^{**}}{2598.06}\, p_T^{CORN} - \underset{(-14.06)^{***}}{1464.72}\, p_T^L + \underset{(11.59)^{***}}{6809.24}\, S_t^1 + \underset{(15.20)^{***}}{10781.4}\, S_t^2$$

$$+ \underset{(12.89)^{***}}{9544.07}\, S_t^3 + \underset{(5.76)^{***}}{4104.83}\, S_t^4 + \underset{(0.99)}{596.63}\, S_t^5$$

$$\bar{R}^2 = .891,\ \text{D-W} = 0.91^{1/},\ \hat{\rho} = .49$$

Discussion of the Market Milk Estimates

Given the discussion of the short-run constant income stream objective (pages 32-33), relatively small and/or insignificant coefficients on m_L^{Aj} and m_{L-1}^{Aj} would not be surprising. Negative coefficients even with questionable significance are, however, rather surprising. In order to be certain that the negative signs are not a function of the particular specification used, a series of alternative specifications, particularly on the lag structure, were investigated. The negative short-run coefficients appeared consistently in these specifications. Since most price changes in the time period considered (1958-1973) were small, it may be that the short-run constant income stream objective prevails for small price changes. It is unlikely this response would hold for large price changes.

The unambiguous direction and importance of the capacity decision is indicated by the response to the third and fourth lagged margin variable. These coefficients are much more significant than the short-run variable; consequently, the long-run response to an increased (decreased) margin is positive (negative) as expected.

1/ The hypothesis of positive autocorrelation is accepted. An analysis of the residuals indicates there is one or more factor(s) affecting manufacturing milk producers that has not been delineated. All attempts to isolate such factor(s) were unsuccessful.

The seasonality of milk production is manifested in the significance of the dummy variables. Production is significantly greater than in January-February in all periods except November-December. As Table 9 illustrates, differences among the regions do exist. Seasonal adjustments in production are less pronounced in the Southern California and the Central Coast regions.

TABLE 9

The Effect of Seasonality on Production by Regions
with the Coefficient on the Dummy Variables Expressed as a Percentage
of Average Production in the Region

Region	March-April	May-June	July-August	Sept.-October	November-December
Southern California	3.25	4.07	0.74	0.47	-0.90
Southern San Joaquin	4.84	11.04	11.54	7.38	0.57
Northern San Joaquin	7.00	12.52	11.55	5.86	-0.29
Coast	5.33	5.68	3.83	1.44	-0.53
Mountains	18.33	31.10	22.81	10.79	1.92
California	5.17	8.23	6.48	3.53	-0.37

When a regression was run with California market milk as the dependent variable, the $\bar{R}^2$ was high but the significance of most coefficients was less than in the regional equations. This situation illustrates that a factor of importance in one region may be diluted when total market milk production is considered. Although the $\bar{R}^2$ cannot strictly be compared among regions since the $\hat{\rho}$'s are different, the results suggest that relatively larger unexplained variation exists in Southern California and the Central Coast where urban pressure is great and in the Mountain Areas and North Coast where only a little over one percent of market milk is produced. The importance of the urban pressure may introduce forces that are not specified in the equations.

All regions except the Mountain Areas exhibit a significant trend toward increased production. This trend is a proxy for increased production per cow and increased herd size due to improvements in technology, genetics, and management. A part of the improvement in management is separately included in most regions by the proxy dhi_T variable. The largest time trend is in the Southern San Joaquin region; a region that has been increasing production rapidly with dairies relocating from other regions, primarily Southern California. The individual regional equations are discussed further in the subsections that follow.

Southern California

Southern California dairies are typically very large, industry-type operations that purchase nearly all feed inputs and operate with large quotas. Due to the large quotas and the lack of alternatives resulting from the high degree of specialization, there is little aggregate short-run reaction to changes in margin per cow. Short-run reactions of the two types presented above seem to cancel out in the first year while a little of the "income stream" adjustment carries over to the second year. Capacity adjustments (long-run) occur more rapidly in this region, probably because management is better and because production has been increasing less rapidly indicating fewer large capacity adjustments. The latter factor is also reflected in the importance of beef prices. With fewer capacity adjustments producers have more latitude to cull cows when beef prices are high. On the other hand, the price of beef is less significant than one might expect. This may be due to the dairies being specialized and production per cow so high that the beef price only marginally affects culling decisions. The significance of the land price eminates from the general competition of feed inputs with other crops and the increased difficulties, apart from price, encountered in obtaining feed supplies when competitive crops and thus land prices are high.

Southern San Joaquin Valley

The Southern San Joaquin region has been characterized by rapid increases in production and by an accelerated movement toward larger, more specialized dairies similar to those found in Southern California. The aggregate short-run response is again almost insignificant. Because much of the production increase is created by new dairies or by large capacity increases, the capacity adjustments are not as rapid as in Southern California, and the costliness of borrowing money (the interest rate) shows some significance. As in the Southern California region, the index of land prices has a strong negative effect on production. Production is unaffected by beef prices probably because of the large capacity increases requiring all available quality cows and the high degree of specialization present in the region.

Northern San Joaquin and Sacramento Valleys

The results from this region with dairies that raise much more of their feed inputs but still are firmly entrenched in milk production are perplexing. Although still minor, the aggregate short-run response to margin is larger than in the previous regions. The capacity adjustment again continues into the fourth year.

The perplexing aspect of this equation is that none of the opportunity cost variables that should negatively affect production -- P_T^{BF}, P_T^{L}, P_{T-2}^{INT} -- appears in the final equation. It is not surprising when one or two of the variables are excluded since all three may not be important in a particular region and since there is colinearity between the three and with dhi_T and TM; however, the absence of all three is unexpected. It may be that the interest rate is less important because capacity adjustments are smaller, beef price is insignificant because it affects the culling rate only marginally, and land price is reflected in the margins since many more producers grow their own feed inputs.

Central Coast

The results for the Central Coast region are also unexpected with no capacity adjustment to margin. Since production has remained constant in this region, with smaller dairies possessing high quotas and facing pressures from urban expansion, further analysis indicates the results may not be unreasonable. Many producers are primarily interested in a constant income stream which they acquire by increasing production when margins shrink and by culling cows when beef prices are high. In general, dairymen in this area have not purchased larger dairies elsewhere in the region when urban expansion has forced them to move or sell out, as has been the case in Southern California.

Mountain Areas and North Coast

The typical dairy in this region is much smaller, much less specialized, and more marginal than market milk firms in the other regions. This situation is reflected in the large positive short-run reaction to margin. When the margin increases, production is increased; when profitability declines, cows are culled and herds are liquidated. The coefficients on m^{A5}_{L-2} and m^{A5}_{L-3} indicate that capacity adjustments occur less rapidly than in other regions primarily because many producers raise their own replacements. The reactions to interest charges and beef prices reflect the more marginal nature of production in this region. The land price variable is not included since this region is so different from the state as a whole. This is the only region failing to exhibit a ceteris paribus trend of increased production.

Discussion of the Manufacturing Milk Estimates

When compared to market milk dairies, typical manufacturing milk dairies are much smaller, have lower production per cow, and are much more diversified. Although the three price variables possess severe multicolinearity, each is significant at the five percent level. In addition, the price of corn has an important negative effect on production. The corn price had a more significant effect than did the price of 16 percent dairy feed. Hay price did not show a significant effect probably because most producers raise their own roughage and apparently fail to recognize the opportunity cost of feeding the roughages to their cows. The extreme significance of the land price reflects the diversification typical of these firms with the land price serving as a proxy for the profitability of raising cash crops that compete with feed inputs.

The unexpected deletion of beef price can probably be attributed to the presence of multicolinearity.

Analysis of Supply Response

A meaningful comparison of the results of this study with other studies is limited because: (1) the dairies in California are typically much larger and more specialized than dairies in other states, (2) production in this study is separated into market and manufacturing milk, (3) the bimonthly observations, and (4) the lag structure employed. The reader should remain cognizant of these dissimilarities throughout the following discussion.

Supply Elasticities

Table 10 contains the margin and price elasticities for the estimated equations presented above. The margin elasticities are small since a one percent change in margin is created by a much smaller change in price or costs. To obtain a margin elasticity value comparable to price elasticity, the percentage change in margin created by a one percent change in price is determined (all calculation using mean values and the most recent values).[1/] This percentage is then multiplied by the margin elasticity to derive a value that can be compared (with the appropriate qualifications) with price elasticities. Limited analysis with equations containing price indicated that these values are slightly higher than price elasticities for the market milk regions; however, the indicated differences are small enough that the calculated values can be compared with price elasticities for manufacturing milk and all milk, and with price elasticities in other studies.

[1/] The value is calculated by multiplying one percent of the price by the production per cow. The number is then divided by the margin per cow and converted to a percent.

TABLE 10

Margin and Price Elasticities for Milk Produced in California

Area of Production, Time Period, and Equation	Margin Elasticity		Price Elasticity		Comparable Value	
	Mean Values	Nov-Dec 1973 Values	Mean Values	Nov-Dec 1973 Values	Mean Values	Nov-Dec 1973 Values
Southern California (Equation B.1)						
L-1	-.011	-.015			-.066	-.086
L-2	.050	.067			.323	.370
Total	.040	.052			.257	.284
South San Joaquin (Equation B.2)						
L-1	.016	.031			.141	.160
L-2	.018	.042			.186	.201
L-3	.017	.046			.217	.218
Total	.051	.119			.543	.579
North San Joaquin (Equation B.3)						
L	-.019	-.020			-.119	-.154
L-1	-.033	-.060			-.214	-.260
L-2	.068	.136			.496	.587
L-3	.046	.094			.390	.423
Total	.062	.140			.552	.596
Central Coast (Equation B.4)						
L	-.031	-.032			-.200	-.306
Mountains (Equation B.5)						
L	.124	.291			.630	1.334
L-2	.068	.184			.377	.740
L-3	.093	.289			.566	1.054
Total	.285	.764			1.573	3.128
Manufacturing Milk (Equation B.12)						
L			1.315	3.242		
L-1			1.424	3.219		
L-2			.852	1.941		
Total			3.591	8.402		
All Milk						
L			.425	.522		
L-1			-.460	-.511		
L-2			.252	.283		
L-3			.706	.781		
Total			.924	1.075		

The elasticities labeled "total"[1/], which are the sum of the yearly elasticities, are reasonable when compared to the long-run elasticities derived in other studies and summarized in Table 5.[2/] Most researchers have found long-run elasticities in the range of 0.4 to 1.0. Since the price elasticities are at least approximately comparable to the "comparable value", the major production areas for market milk--Southern California, South and North San Joaquin--fall at the lower end of this range. The elasticity for all milk production of .924 is very close to the elasticity of 1.04 recently derived for California, Washington, and Oregon by Hammond [1974].

The difference in elasticities among the regions and the types of production is revealing. The market milk regions of Southern California and Central Coast regions, both with significant urban pressures and high quotas, have a very inelastic market milk supply response. The Central Valley market milk production regions maintain a somewhat less inelastic response. These areas of large, specialized dairies have a more inelastic response presumably because even in the long run they are firmly entrenched in the dairy industry. The smaller, less specialized dairies in the Mountains and those producing manufacturing milk possess an elastic supply response. The very elastic supply response obtained when manufacturing milk firms are isolated reflects the diversification and ease of transfer from the industry typical of these producers.

Elasticities for Costs and Opportunity Costs

In the results presented in the preceding section, dairymen in all regions except North San Joaquin and Sacramento Valleys exhibit a

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[1/] The total or the sum of the elasticities for individual years is an approximation of the long-run elasticity. Since the individual elasticities are the percentage change in production for a one percent change in margin L-i years ago, the sum gives the total percentage change in production resulting from a one percent change in margin. This procedure is consistent with Wilson and Thompson [1967] for a finite series and with the procedure used to derive the long-run elasticity in the partial adjustment hypothesis. In this case the sum is a geometric series.

[2/] No equivalent elasticities are available for comparison with the elasticities for individual years.

significant response to one or more variables representing the costs and opportunity costs of producing milk. The elasticities for these responses are summarized in Table 11. As was the case with the response to producer returns, the smaller and more diversified market milk producers in the Mountain region and manufacturing milk producers are much more responsive than the large, specialized market milk producers.

Percent Fat and Solids

Wilson and Thompson [1967] found production per cow and the proportion of cows bred artificially to exert a significant effect on the fat percentage. No similar relationship is found to characterize the fat percentage in California production. In fact, the following equation, containing only dummy variables for seasonality and a time trend, captures the downward trend in fat percentage characteristic of this period.

$$\text{(B.13)} \quad PCF_t = \underset{(422.78)^{***}}{3.845} - \underset{(-16.51)^{***}}{0.176\, S_t^1} - \underset{(-28.69)^{***}}{0.306\, S_t^2} - \underset{(-29.40)^{***}}{0.314\, S_t^3}$$

$$- \underset{(-16.29)^{***}}{0.174\, S_t^4} + \underset{(0.39)}{0.004\, S_t^5} - \underset{(-9.07)^{***}}{0.00125\, TM}$$

$$\bar{R}^2 = .959, \quad D\text{-}W = 1.26^{1/}$$

Processor and Consumer Subsectors

Because the simultaneous subsystem contains elements of both the processor and consumer subsectors, the results from the remaining behavioral equations are discussed in this section. The results for the manufacturing milk price (relationship 17 in Table 7) are discussed first. Results for the retail value of fat and solids in products (relationships 22 and 23) and the per capita consumption of fluid milkfat and fluid skim milk (relationships 24 and 25) are then presented. The simultaneous subsystem is included in these equations. Finally, the estimates of the demand for fats and solids in products (relationship 27) is detailed.

1/ This value is in the indeterminant region at the one percent significance level.

TABLE 11

Elasticities Indicating the Responses of Milk Production to Costs and Opportunity Costs

Area of Production	Interest Rate (T-2)		Beef Price (T)		Index of Land Prices (T)		Price of Corn (T)	
	Mean Values	Nov-Dec 1973 Values	Mean Values	Nov-Dec 1973 Values	Mean Values	Nov-Dec 1973 Values	Mean Values	Nov-Dec 1973 Values
Southern California (Equation A.2)			-.037	-.058	-.424	-.506		
South San Joaquin (Equation A.3)	-.079	-.063			-1.203	-1.164		
Central Coast (Equation A.4)			-.207	-.386				
Mountains (Equation A.5)	-.273	-.318	-.480	-1.185				
Manufacturing Milk (Equation A.12)					-5.041	-11.334	-.250	-.778
All Milk					-.565	-.670	-.122	-.204

Manufacturing Milk Price

The following estimates are attained using the generalized least squares procedure discussed in the previous section:

$$(B.17) \quad P_t^B = \underset{(2.31)^{**}}{0.242} + \underset{(1.63)^{*}}{0.0986}\, SP_t + \underset{(15.79)^{***}}{0.893}\, PMP_t - \underset{(-2.53)^{***}}{0.00345}\, TM - \underset{(-2.23)^{**}}{0.0716}\, S_t^1$$

$$- \underset{(-1.83)^{**}}{0.0629}\, S_t^2 - \underset{(1.37)^{*}}{0.0475}\, S_t^3 - \underset{(-0.66)}{0.0206}\, S_t^4 + \underset{(1.60)^{*}}{0.0498}\, S_t^5$$

$$\bar{R}^2 = .990,\ D\text{-}W = 0.97^{1/},\ \hat{\rho} = .37$$

The results indicate that the principal explanatory variable for manufacturing milk price is the hundredweight equivalent of market milk prices for classes 2 through 4 fats and solids (PMP).[2/] Additional explanatory power emanates from the Federal support price for manufacturing milk, a time trend, and seasonality. The negative time trend indicates that the manufacturing milk price is losing about two cents per year in comparison with the controlled prices. Manufacturing milk prices are highest in November-December and lowest in March-April, everything else equal; however, the range is only about twelve cents. These results appear to be reasonable in light of the extreme price control in the dairy industry. Prato [1973] estimated a similar relationship for the price nationally and found the Federal support price to be the prime explanatory variable.

Behavioral Equations for Retail Value of Fat and Solids in Products and Consumption of Fluid Products

Four behavioral relationships are discussed in this section: (1) the retail value of fat in products (relationship 22 in Table 7); (2) the

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[1/] The hypothesis of positive autocorrelation is accepted. Although undesirable, given the purpose of the study, the presence of autocorrelation even after the autoregressive transformation is not too worrisome with an $\bar{R}^2$ of .990.

[2/] The fat and solids prices are converted to a hundredweight because manufacturing milk is still priced on a hundredweight basis with a butterfat differential.

retail value of solids in products (relationship 23); (3) per capita consumption of fluid milkfat (relationship 24); and (4) per capita consumption of fluid skim milk (relationship 25). The first relationship, which is not part of the simultaneous subsystem, is estimated by ordinary least squares (OLS); the other three relationships are part of this system and are estimated by two stage least squares (TSLS).[1/]

Retail Value of Fat in Products

The equation for the retail value of fat in products is not a part of the simultaneous subsystem since the endogenous variables included in the right hand side are determined recursively because the hypothesis that fluid skim and/or fluid milkfat are substitutes for fat in products is rejected. The behavioral equation estimated by ordinary least squares is:

$$\text{(B.22)}\quad RFP_t^m = \underset{(-5.41)^{***}}{-0.881} + \underset{(7.82)^{***}}{1.241}\, APF_t + \underset{(1.76)^{**}}{0.373}\, APS_t + \underset{(0.63)}{0.0238}\, XMCH_t$$

$$+ \underset{(0.68)}{0.0013}\, SB_t + \underset{(5.92)^{***}}{0.0460}\, CHESF_t - \underset{(-6.77)^{***}}{0.0093}\, TM + \underset{(2.43)^{***}}{0.0353}\, S_t^1$$

$$+ \underset{(3.36)^{***}}{0.0715}\, S_t^2 - \underset{(-0.89)}{0.0107}\, S_t^3 + \underset{(0.61)}{0.0089}\, S_t^4 + \underset{(2.64)^{***}}{0.0475}\, S_t^5$$

$$\bar{R}^2 = .974,\ D\text{-}W = .79^{2/}$$

[1/] The complete simultaneous subsystem is relationships 18-21 and 23-26 of Table 7. As the results indicate the simultaneity is tenuous. Ordinary least squares estimates of equations very similar to these were deemed less desirable.

Although most of the estimated equations possess positive autocorrelation, no corrective measures are attempted for two reasons. First, since no means of correcting for autocorrelation in simultaneous systems of equations is known to the author, the comparison of the results would be hindered. Further, the high $\bar{R}^2$ in most equations indicates that although the residuals are correlated, they are so small the importance of the correlation is questionable.

It is recognized that both the $\bar{R}^2$ statistic and the Durbin-Watson statistic are invalid for simultaneous equations. They are presented as they provide indication of the properties of the estimated equation. In the analysis of almost identical equations estimated by ordinary least squares and two stage least squares, the statistics from the two are almost identical.

[2/] The hypothesis of positive autocorrelation is accepted.

The variables included, the signs, and the magnitudes of the coefficients are consistent with expectations based on economic theory and knowledge of the industry. The marketing margin for fat in products appears to be primarily a percentage markup with *ceteris paribus* price increases larger at the retail than the farm level. The coefficient and the significance of the labor cost variables (XMCH) is less than might be expected, possibly due to multicolinearity. Also the support price for butter is less significant than might be expected probably because of close correlation with the support price for manufacturing milk which is a partial determinant of the average price paid for solids. The positive, highly significant coefficient on the proportion of fat used in cheese production (CHESF) reflects the high degree of marketing services associated with cheese production. The negative coefficient on the time trend indicates that *ceteris paribus* the marketing margin has been shrinking about one cent per bimonthly period.

Simultaneous Subsystem

Two stage least squares are used to estimate the three behavioral equations in the simultaneous subsystem--the retail value of solids in products, per capita consumption of fluid milkfat, and the per capita consumption of fluid skim milk (relationships 23-25 in Table 7). The results are:

$$\text{(B.23)}\quad RSP_t^m = \underset{(-8.99)^{***}}{-\,0.274} + \underset{(15.48)^{***}}{1.686\ \hat{APS}_t} + \underset{(3.37)^{***}}{0.0809\ XMCH_t} + \underset{(1.45)^{*}}{0.00404\ CHESS_t}$$

$$\underset{(-10.17)^{***}}{-\,0.00300\ TM} + \underset{(0.03)}{0.00019\ S_t^1} + \underset{(0.18)}{0.00138\ S_t^2} - \underset{(-0.01)}{0.000073\ S_t^3}$$

$$\underset{(-1.47)^{*}}{-\,0.0122\ S_t^4} - \underset{(-0.36)}{0.00236\ S_t^5}$$

$$\bar{R}^2 = .992,\ D\text{-}W = 1.57$$

$$\text{(B.24)} \quad RFQF_t = \underset{(4.58)^{***}}{1.47} - \underset{(-0.33)}{0.00155}\, RFLP_t + \underset{(0.52)}{0.0755}\, R\hat{S}P_t^m + \underset{(1.60)^{*}}{0.0247}\, AD_t$$

$$- \underset{(-6.44)^{***}}{0.144}\, XIMIT_t - \underset{(-7.46)^{***}}{0.0039}\, TM + \underset{(3.88)^{***}}{0.043}\, S_t^1 - \underset{(-0.12)}{0.0014}\, S_t^2$$

$$- \underset{(-2.50)^{***}}{0.030}\, S_t^3 + \underset{(6.41)^{***}}{0.072}\, S_t^4 + \underset{(6.68)^{***}}{0.076}\, S_t^5$$

$$\bar{R}^2 = .956,\ D\text{-}W = 0.94$$

$$\text{(B.25)} \quad RSQF_t = \underset{(5.76)^{***}}{48.45} - \underset{(-0.38)}{0.0458}\, RFLP_t + \underset{(0.50)}{1.893}\, R\hat{S}P_t^m + \underset{(0.04)}{0.0145}\, AD_t$$

$$- \underset{(-5.88)^{***}}{3.156}\, XIMIT_t - \underset{(-2.45)^{***}}{0.0338}\, TM + \underset{(3.58)^{***}}{1.05}\, S_t^1 - \underset{(-1.04)}{0.321}\, S_t^2$$

$$- \underset{(-3.05)^{***}}{0.947}\, S_t^3 + \underset{(7.28)^{***}}{2.133}\, S_t^4 + \underset{(2.98)^{***}}{1.109}\, S_t^5$$

$$\bar{R}^2 = .841,\ D\text{-}W = 0.93$$

The equation for retail value of solids in products is similar to the equation for fat presented above. The marketing margin again appears to be a percentage markup where farm-level price changes are nearly doubled by the time they reach the consumer. As expected, increases (decreases) in labor costs increase (decrease) the marketing margin. The response to the proportion of solids used in cheese production again is positive, and ceteris paribus the marketing margin is shrinking.

When Equations B.24 and B.25 are adjusted for the differences between a pound of fat and a pound of skim milk, most of the coefficients in the two equations are almost identical. The two differences are (1) the age distribution variable appears to have some effect on the demand for fat only and (2) the coefficients on the time trend reflect the expected result that the demand for fat is declining more rapidly than the demand for skim milk. Because of these differences, the separate specification of fat and skim milk is retained in the model; however, the equations are analyzed together in the following paragraphs.

A general conclusion that can be drawn from Equations B.24 and B.25 is that the demand for fluid milk products is explained primarily by exogenous variables: concern over cholesterol, downward trend in consumption, and seasonality. The per capita consumption of imitation milk products (XIMIT) has a greater impact than simply substitution. The author hypothesizes that this large impact results from the variable serving as a proxy for the level of consumer concern over cholesterol. Per capita consumption is indicated to be declining about 0.2 pound of fluid milk per year, ceteris paribus. Consumption is relatively high in September through December and relatively low in May through August. The seasonality problem in the dairy industry is illustrated by comparison with seasonality in production (Table 9, page 59) which is highest in May-August and lowest in November-February.

The elasticities in Table 12 indicate that the demand for fluid milk products is inelastic; however, the significance of the coefficients (see Equations B.24 and B.25) is very low. This inelasticity is further indicated by constructing a confidence interval on the demand coefficients. When a 95 percent one-sided confidence interval is constructed on the coefficient for retail milk price in the demand equations for fluid milkfat (B.24) and fluid skim milk (B.25) and an elasticity is computed from the limit using mean values, it is determined that with 95 percent probability the demand for milk is more price inelastic than -0.28.

Although the inelasticity is consistent with a food that has few food substitutes and is considered to be a basic element in every diet, the elasticities in Table 12 are more inelastic than is generally accepted for fluid milk. Wilson and Thompson [1967] found a price elasticity of -0.31. Prato [1973] found a price elasticity of -0.105 with a t-ratio of 0.563.

There is some indication that California consumers may be more price inelastic than the national average. Forker [1965] was unable to obtain a negative coefficient on price, and Johnson [1967] completely excluded the price variable in an extensive analysis of demand for milk in California. A possible explanation is that consumers lost their consciousness of price when the controlled price remained constant for months at a time.

TABLE 12

Elasticities for the Consumption of Fluid Milkfat and Fluid Skim Milk

Product and Equation	Milk Price Elasticity		Cross-Elasticity with Value of Solids in Products	
	Mean Values	Nov-Dec 1973 Values	Mean Values	Nov-Dec 1973 Values
Milkfat (B.24)	-0.048	-0.068	0.017	0.043
Skim Milk (B.25)	-0.051	-0.067	0.015	0.036

Consumption of Fat and Solids in Products

The ordinary least squares estimates of the final relationship in the model--per capita consumption of fat and solids in products--are as follows:

$$(B.27)\quad RMDQ_t = \underset{(7.94)^{***}}{2.94} - \underset{(-5.18)^{***}}{0.477\ APF_t} - \underset{(-1.83)^{**}}{0.577\ APS_t} + \underset{(1.58)^{*}}{0.0109\ RFLP_t}$$

$$+ \underset{(5.44)^{***}}{0.00059\ Y_t} - \underset{(-9.58)^{***}}{0.0221\ TM} + \underset{(10.60)^{***}}{0.172\ S_t^1} + \underset{(20.01)^{***}}{0.343\ S_t^2}$$

$$+ \underset{(24.83)^{***}}{0.437\ S_t^3} + \underset{(35.74)^{***}}{0.570\ S_t^4} + \underset{(43.85)^{***}}{0.699\ S_t^5}$$

$$\bar{R}^2 = .968,\ D\text{-}W = 0.83^{1/}$$

Table 13 indicates that the demand for manufactured dairy products is more elastic than the demand for fluid products. The income elasticities are particularly significant, and they compare favorably with those of Wilson and Thompson [1967], who found an income elasticity of 0.60 for fat and 0.71 for solids. The price elasticities are similar to those determined by Wilson and Thompson [1967]

1/ The hypothesis of positive autocorrelation is accepted.

and Prato [1973]. Exact comparison with other studies is not possible since each study has a different scheme for deriving the value of fats and solids. As with fluid milk products, consumption is declining *ceteris paribus*.

TABLE 13

Elasticities for the Consumption of Fats and Solids in Manufactured Dairy Products

Elasticity with	Mean Values	Nov.-Dec. 1973 Values
Retail Value of Fat	-0.192	-0.236
Retail Value of Solids	-0.035	-0.119
Fluid Milk Price	0.139	0.169
Income	0.495	0.734

Evaluation of the Model

Before proceeding to simulate future values of the endogenous variables, it must be determined whether, in fact, the model will generate meaningful values of the endogenous variables. Three kinds of tests are applied. First, through the development of the model and the derivation of the evaluation measures to be discussed below, it was concluded that the model is superior to naive models such as "the same as last year" or "the same change as last year". A look at actual versus predicted values provides graphic proof that this conclusion is correct.

The second aspect of the evaluation procedure was to investigate the stability of the model. Since nonlinearities appeared in the identities, the dynamic properties could not readily be derived. Instead the following procedure was employed. Using the exogenous and control variables for the final year of the data series, 1973, the model was allowed to generate new endogenous variables until it stabilized or exploded. All lagged and recursive endogenous variables are composed of predicted values. When this procedure was performed, there was a minimal amount of adjustment among the endogenous variables; however, within six to eight years all values had stabilized at reasonable levels.

The third and most important part of the evaluation procedure was to allow the model to generate a new time path for all endogenous variables. This is accomplished by using the actual values of all exogenous variables and the predicted values for all lagged endogenous variables and for all endogenous variables entered in recursive relationships. This procedure is designed to test whether the model has any inadequacies that would allow one or more variables to drift away from the actual time series. It should be noted that as French and Matsumoto [1970] point out, this procedure is sensitive to the starting point of the analysis. If the lagged endogenous variables for the initial period are out of equilibrium the predicted values from the model may deviate from actual values for some time.

In order to evaluate the results of the above procedure, the following two measures are calculated for levels of the key endogenous variables over the seventy-eight period (1961-1973, bimonthly observations). Comparisons of levels utilize the values of the actual and predicted endogenous variable in each time period.

1. Percent Mean Forecast Error is of Mean Value.
   Mean forecast error is simply the average difference between the actual and predicted level
   $[\sum_{t=1}^{N} (A_t - P_t)/N]$ where A_t is actual level, P_t is predicted level, and N is the number of time periods. This value is then divided by the average level of the variable.

2. Percent Mean Absolute Forecast Error is of Mean Value.
   Mean absolute forecast error is the average error disregarding the sign.
   $(\sum_{t=1}^{N} |A_t - P_t| / N)$
   This value is again divided by the average level of the variable.

In addition to these single-valued measures, tracking measures are presented to evaluate the ability of the model to correctly foresee the occurence of turning points. Table 14 provides a convenient method of summarizing the incidence of the four possible combinations of actual and predicted turning points.[1/] In this table, a and d give the number of each of the two types of correct forecasts; b and c provide the number of periods in which each of the two types of errors occur. From this table the proportion of false turns $(\frac{b}{b + a})$ and missed turns $(\frac{c}{c + d})$ can be calculated with ratios close to zero indicating accurate forecasts.

TABLE 14

Summary of Occurence and Non-occurence of
Actual and Predicted Turning Points

Actual \ Predicted	No Turning Point	Turning Point
No Turning Point	a	b
Turning Points	c	d

These measures are summarized in Table 15 for the important endogenous variables in the model.[2/] The magnitude of the figures indicates satisfactory performance of the model. Only four of the variables had more than two percent error in the mean absolute forecast error. Most of the variables had predominantly correct (a + d) prediction of turning points.

[1/] See Theil [1961] and Zarnowitz [1967] for examples of the use of this summary table.

[2/] A much more detailed presentation of these measures is contained in Milligan [1975a].

TABLE 15

Evaluation Measures Comparing Actual Values with Values Predicted by the Model for Selected Endogenous Variables using 1961-1973 Bimonthly Observations

Relation (Relation number in parentheses)		Percent Mean Forecast Error is of Mean Value	Percent Mean Absolute Forecast Error is of Mean Value	Tracking Measures (See Table 14 for a - d)			
				a	b	c	d
Daily Market Milk Production							
Southern California	(1)	0.03	1.31	27	14	14	21
South San Joaquin	(2)	-0.02	1.83	45	6	6	19
North San Joaquin & Sacramento	(3)	-0.02	2.08	40	9	11	16
Central Coast	(4)	0.12	1.58	36	11	15	14
Mountain & North Coast	(5)	-0.10	3.05	50	1	1	24
All Market Milk	(6)	0.02	1.44	46	5	5	20
Daily Manufacturing Production	(7)	-1.42	5.80	49	2	2	23
Percent Milkfat	(8)	0.00	0.58	42	9	9	16
Percent Solids-not-fat	(9)	-0.00	0.11	42	10	9	15
Manufacturing Milk Price	(10)	-0.06	1.36	42	5	7	22
Ave. Price Paid for Fat	(13)	-0.04	0.45	40	9	6	21
Ave. Price Paid for Solids	(14)	-0.01	0.48	48	8	4	16
Consumption of Fluid Milkfat	(15)	-0.36	1.26	18	9	7	42
Consumption of Fluid Skim	(16)	-0.33	1.19	21	4	4	47
Consumption of Fluid Milk	(17)	-0.33	1.19	21	4	4	47
Retail Value of Solids	(18)	-0.18	2.87	31	13	9	23
Retail Value of Fat	(19)	-0.02	1.53	21	20	11	24
Market Milk Price	(21)	-0.07	0.50	45	4	4	23
Consumption of Fat & Solids in Products	(27)	0.01	0.86	52	0	0	24

SIMULATION OF THE CALIFORNIA DAIRY INDUSTRY

In this section the development of and the results from the model utilized to simulate future values of the endogenous variables of the California dairy industry are discussed. This model employs (1) the coefficients from the model just presented and (2) predicted time paths for the exogenous and control variables to estimate the effects on the California dairy industry of selected alterations in the time paths of control and exogenous variables.

To avoid the problem of uncountable combinations of alternative time paths for control and exogenous variables, the simulation procedure is to initially specify a base model. This base model contains predicted time paths for all exogenous and control variables for 1974-1985 and simulated time paths for all endogenous variables. 1985 is chosen as the termination date because it allows sufficient time to measure the effects of lagged variables and because projecting to 1985 is somewhat standard. Simulations are then executed by altering the time paths of exogenous and control variables and comparing the results with the base model.

Prediction of Future Exogenous Variables

The inclusion of a sophisticated econometric model to predict the future values of exogenous variables is beyond the scope of this study. Various alternatives are available, however. Two very simple predictive devices are (1) to assume that there is no change since the previous bimonthly period or since the same bimonthly period a year ago and (2) to assume that the change is occurring at the same rate as the last period or year for which observations are available. Two techniques that should produce more accurate predictions are to project each exogenous variable based on the trend anticipated by the researcher and to estimate an integrated autoregressive-moving-average (ARIMA) process for each exogenous variable. An application of incorporating expected trends is provided by French and Matsumoto [1970]. The ARIMA process was devised by Box and Jenkins [1970]. Further explanation including examples is provided by Nelson [1973].

For many of the key exogenous variables in the processor and consumer subsectors--population, income, etc.--projections are published by governmental agencies. In addition, employees of the Bureau of Milk Stabilization are extremely knowledgeable concerning anticipated changes in the levels of the exogenous variables affecting the producer subsector. Consequently, the future values of the exogenous variables are predicted based on anticipated trends for each variable.

There are forty-two exogenous and control variables (see Table 7, pages 48-53) that require future time paths. Although not all data series for 1974 were available when the simulations were executed, enough information was available to recognize that many of these variables registered abnormal values during 1974. Consequently, many predicted values for 1974 are based on actual observations for all or part of the year.

For 1975 and beyond, linear trends are specified based on past trends, published projections, and expectations of the author. The unusually high price level for feed inputs and consequently milk prices in 1974 is reflected in the predicted values. No consensus has emerged concerning the future direction of feed prices. Few expect the prices to return to the levels of 1972 and before; however, the prices could decline somewhat or continue upward depending upon world production and demand conditions. In the absence of any consensus, it is assumed that feed prices and milk prices will remain at the current high levels, but no additional increases will occur until 1978. At that time feed and milk prices are projected to return to a "normal" gradual increase.

In arriving at the following projected trends the following procedure was employed. All exogenous variables were considered first, followed by the control variables for class 2-4 prices. These prices, although control variables, must be closely aligned with Federal milk market order prices. Finally, the class 1 prices and the fluid milk price were established at levels which approximately maintained producer returns at past levels and retained stable supply and demand conditions in the California dairy industry.

The reader should remain cognizant of the fact that any prediction of future trends contains some degree of arbitrariness. The level of this arbitrariness is increased by the unstable trends currently exhibited by many variables. As a result, the analysis of this section emphasizes the relative changes in endogenous variables resulting from alterations in control and exogenous variables rather than the absolute levels of the variables.

The trends employed for the exogenous and control variables are:

vc^{Aj} Variable cost per hundredweight in region j, j=

1: Southern California. Linear increase from Nov.-Dec. 1973 value ($6.85) to $8.00 in Nov.-Dec. 1974. Constant for 3 years. Then $vc_t^{A1} = vc_{t-1}^{A1} + .03$.

2: Southern San Joaquin. Linear increase from Nov.-Dec. 1973 value ($6.08) to $7.50 in Nov.-Dec. 1974. Constant for 3 years. Then $vc_t^{A2} = vc_{t-1}^{A2} + .03$.

3: Northern San Joaquin. Linear increase from Nov.-Dec. 1973 value ($6.66) to $7.55 in Nov.-Dec. 1974. Constant for 3 years. Then $vc_t^{A3} = vc_{t-1}^{A3} + .03$.

4: Coast. Linear increase from Nov.-Dec. 1973 value ($6.85) to $8.05 in Nov.-Dec. 1974. Constant for 3 years. Then $vc_t^{A4} = vc_{t-1}^{A4} + .03$.

5: Mountains. Linear increase from Nov.-Dec. 1973 value ($6.01) to $7.55 in Nov.-Dec. 1974. Constant for 3 years. Then $vc_t^{A5} = vc_{t-1}^{A5} + .03$.

PPC^j Hundredweight production per cow in the period in region j, j =

1: Southern California. No change in 1974. Then yearly increases equal to 1.5 percent of 1973 production.

2-5: No change in 1974. Then yearly increases equal to 2.0 percent of production in 1973.

P^{CORN} Price received for corn. For 1974-1977 $P_t^{CORN} = 6.00$. Thereafter $P_t^{CORN} = P_{t-1}^{CORN} + .025$.

L^j Differential between average market milk price and market milk price in region j, j = [1]

1: Southern California. $L_t^1 = L_{t-1}^1 - .003$ where $L_0^1 = 0.30$.[2]

2: Southern San Joaquin. $L_t^2 = L_{t-1}^2 + .003$ where $L_0^2 = -0.30$.

3: Northern San Joaquin. $L_t^3 = L_{t-1}^3 + .002$ where $L_0^3 = -0.20$.

4: Coast. $L_t^4 = L_{t-1}^4 - .0015$ where $L_0^4 = .15$.

5: Mountains. $L_t^5 = L_{t-1}^5 - .005$ where $L_0^5 = .50$.

p^{INT} Interest rate. $p_t^{INT} = 10.00$.

p^{BF} Price received for beef in California. Decrease by 4 percent of Nov.-Dec. 1973 level ($42.78) for six periods. Increase by 2 percent of Nov.-Dec. 1973 level for twelve periods. Then $p_t^{BF} = p_{t-1}^{BF} + .25$.

p^L Index of land prices in California. For 1974 and 1975 $p_t^L = p_{t-1}^L + 1.0$ where $p_0^L = 121$. Thereafter $p_t^L = p_{t-1}^L + 0.6$.

dhi Percent of all cattle in California on DHI test. $dhi_t = dhi_{t-6} + 1.0$ where 1973 values are 51.652, 51.783, 51.915, 52.047, 52.178, and 52.310.

H Differential between price processor pays and producer receives. $H_t = 0$.

POP Population of California. Linearization to 1985 of the baseline (Series D-100) population projections in California Department of Finance [1974a, page 9]. $POP_t = POP_{t-1} +$ 50,964 where $POP_0 = 20,281,000$.

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[1] The initial regional price differential is based on past values. Since regional differences are shrinking as producer quotas reach equalization, the differentials are moving toward zero.

[2] The observation for t = 0 is the Nov.-Dec. 1973 observation.

SP Support price for manufacturing milk. Price raised to \$6.75 in March-April 1974. Starting in Jan.-Feb. 1975. $SP_t = SP_{t-1} + .03$.

Y Personal income per capita. $Y_t = Y_{t-1} + 30$ where $Y_0 = 5229.35$.

AD Proportion of the population attending kindergarten through eighth grade. Based on age distribution reports in United States Department of Commerce [1972b], the proportion in this age group will decrease about .15 percent per year. $AD_t = AD_{t-1} - 0.15$ where $AD_{1973} = 14.68$.

XIMIT Per capita consumption of imitation dairy products in California. $XIMIT_t = 0.413$.

XMCH Hourly wage rate for manufacturing dairy products in California. $XMCH_t = XMCH_{t-1} + .03$ where $XMCH_0 = 5.755$.

SB Federal support price for butter. $SB_t = 66.00$.

CHESF Proportion of fat consumed as cheese. $CHESF_t = CHESF_{t-6} + 1.0$ where 1973 values are 48.1, 46.9, 46.2, 49.4, 48.2, and 47.9.

CHESS Proportion of solids consumed as cheese. $CHESS_t = CHESS_{t-6} + 1.0$ where 1973 values are 35.9, 37.5, 38.5, 40.4, 39.2, and 38.2.

TM Time trend. $TM_t = TM_{t-1} + 1$ where $TM_0 = 78$.

S^i Seasonal dummy variable. No change from sector model.

PFP Average price paid by manufactured dairy product processors for market milk fat. For 1974-1976, $PFP_t = .70$. Thereafter $PFP_t = PFP_{t-1} + .001$.

PSP Average price paid by manufactured dairy product processors for market milk solids. Increased to .46 in Jan.-Feb. 1974 and to .52 in Mar.-Apr. 1974. Constant until Jan.-Feb. 1977 after which $PSP_t = PSP_{t-1} + .003$.

PMP Hundredweight equivalent of PFP and PSP. $PMP_t = 3.50 \times PFP_t + 8.70 \times PSP_t$.

C1FP Class 1 price for fat (pound). For 1974-1977 $C1FP_t = .749$. Thereafter $C1FP_t = C1FP_{t-1} + .001$.

C1SP Class 1 price for skim milk (cwt.). After remaining constant at 6.08 for two periods, increases to 7.25 and remains constant until Jan.-Feb. 1974. Thereafter $C1SP_t = C1SP_{t-1} + .03$.

RFLP Retail price for fluid milk. Increases in Mar.-Apr. 1974 by 5 cents (to 70.33) and remains constant through 1977. Thereafter $RFLP_t = RFLP_{t-1} + .20$.

Operation of the Simulation Model

The simulations are performed by computing values of endogenous variables from the coefficients of the model presented in the previous section and the predicted exogenous variables. All disturbance terms are set equal to zero to generate deterministic predictions, which are then expected values--i.e., trend or average levels of the endogenous variables.

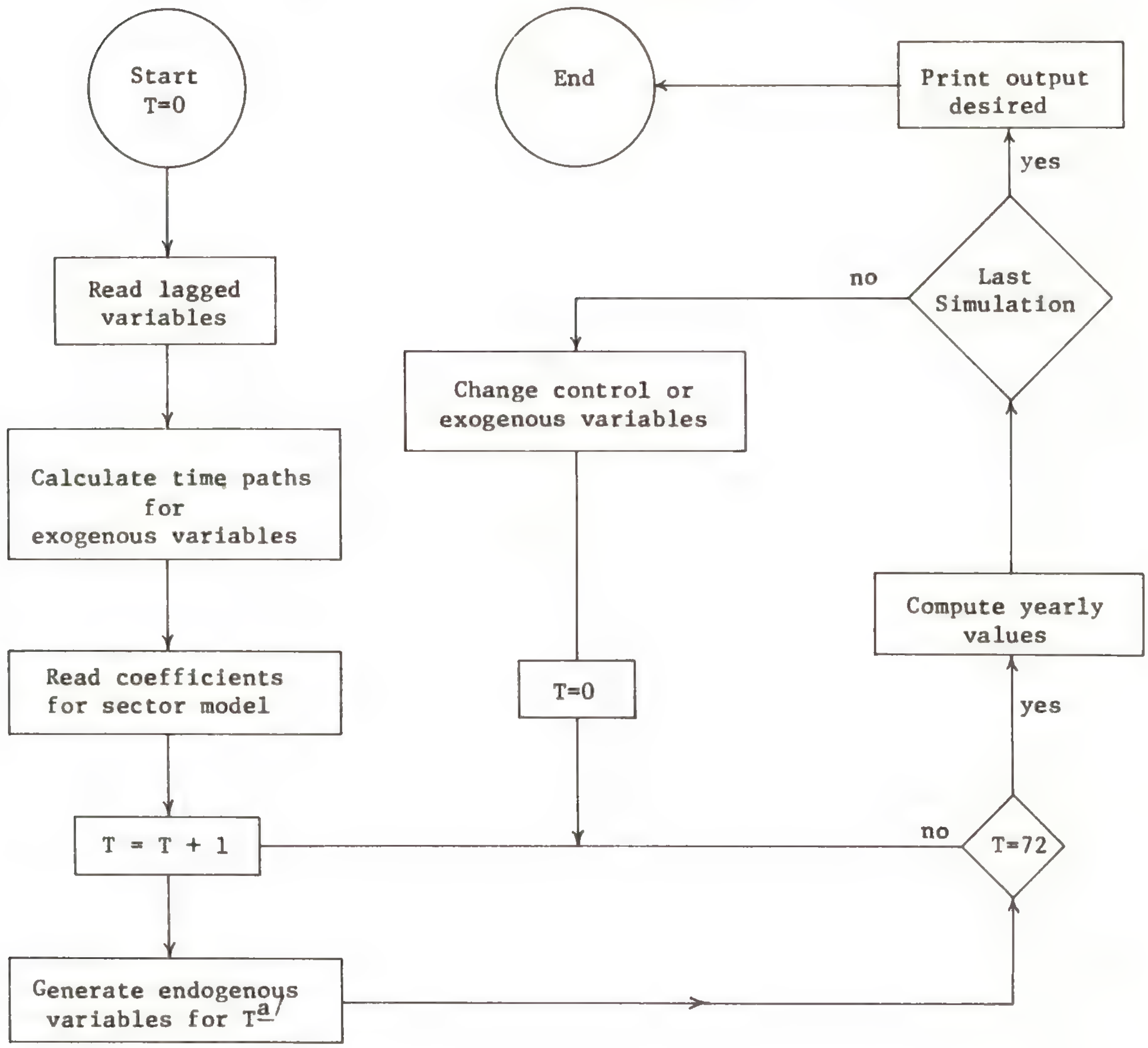
An alternative simulation approach is to include stochastic elements based on the variance of the equations estimated in the preceding section. Although this procedure would provide insight into the sensitivity of the model to random exogenous shocks, the number of computations is increased manyfold since repeated simulation runs are required. Since the expected benefits do not appear to justify the additional cost in time and money, expected values are used.

The operation of the simulation model is illustrated in Figure 10. Using the data required to specify lagged endogenous and exogenous variables and to compute predicted exogenous variables, the time paths for the exogenous variables are computed. The structural model described in the previous section is then used to compute the predicted values of the endogenous variables for bimonthly periods in 1974-1985 (72 periods).

In order to facilitate the presentation of the results of the simulations, the bimonthly observations are converted to yearly values

FIGURE 10

Flow Chart of the Operation of the Simulation Model



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[a] See Figure 11.

by summation or by averaging with the appropriate weights. The execution of these computations completes the first simulation run. Additional simulation runs are then executed with changes in exogenous and/or control variables.

The output for each endogenous variable[1/] includes bimonthly and yearly values for each simulation run and the actual and percentage deviation from the base simulation run for each additional run. These deviations illustrate the impact of the specified changes in exogenous and control variables.

The procedure executed to generate the endogenous variables for each bimonthly period is outlined in Figure 11. After the lagged margin and manufacturing price variables are computed, the production of market milk (by regions), manufacturing milk, percent fat and solids, and manufacturing milk price are predicted from the margin and exogenous variables.

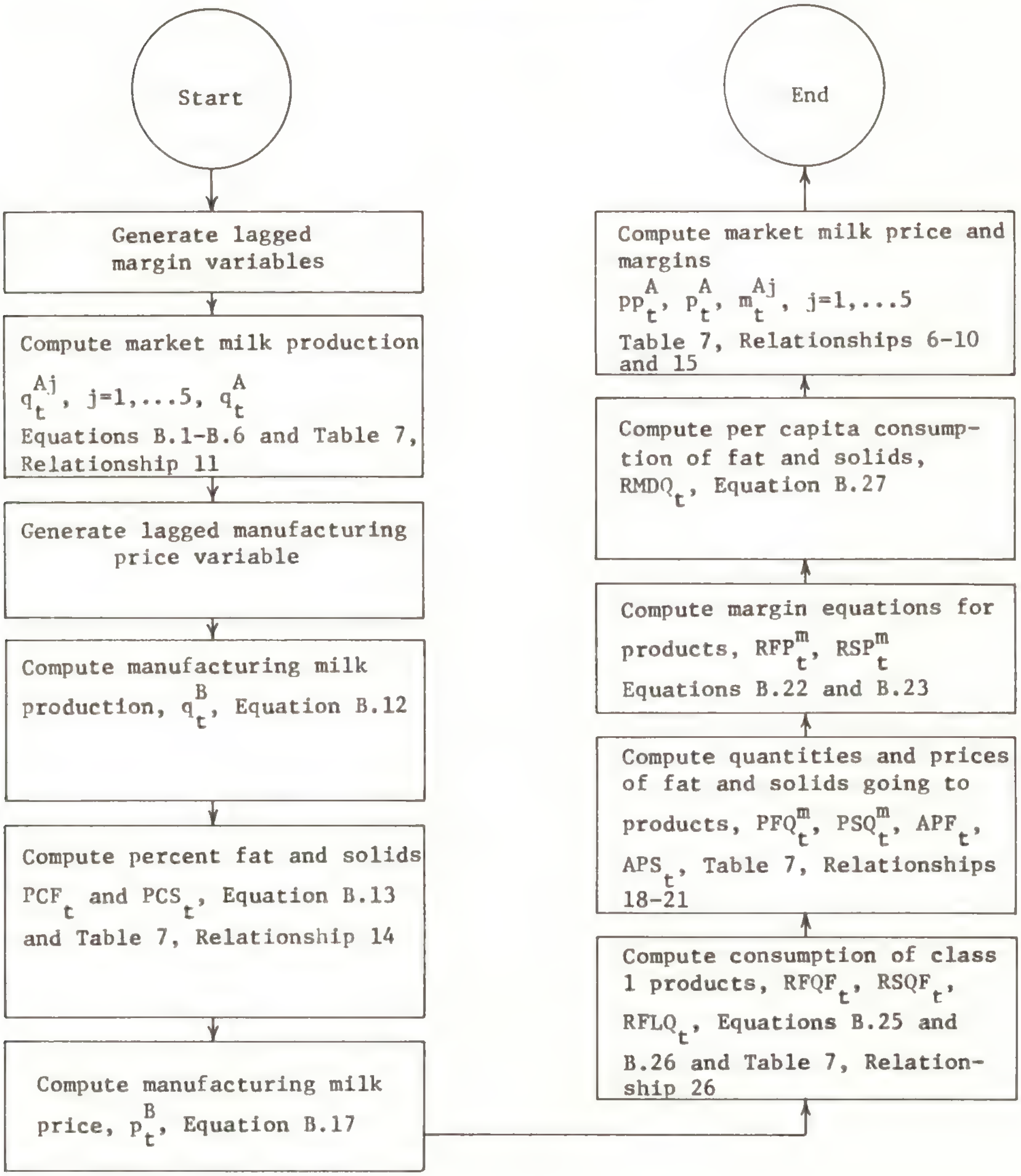
After per capita consumption of class 1 products is determined, the quantities of fats and solids available for processing into manufactured dairy products is calculated. Further, the market and manufacturing milk prices are weighted by the respective quantities to calculate the average price paid for fats and solids processed into products. Given these prices, the margin equations are used to determine the retail value of fats and solids in products. These values are then used to compute the per capita consumption of fats and solids in products.

The average price paid market milk producers is determined by weighting the controlled prices by the utilization of market milk. This price, along with exogenous variables for variable costs, production per cow, and regional price differences, is used to calculate the margin per cow in each region which is utilized in determining production in the following time period.

[1/] Only 26 of the 27 endogenous variables in the sector model are printed out because the average price per cwt. of market milk paid by processors (pp_t^A) and the average price per cwt. of market milk received by producers (p_t^A) are equal in the simulation model.

FIGURE 11

Flow Chart of the Procedure Required to Generate Endogenous Variables for a Given Time Period



The Base Model

One adjustment is required in the model before generating simulation results. In 1974, the first simulated year, the base model predicted negative manufacturing milk production. Three factors contributed to this result: (1) 1974 was a very bad year for manufacturing milk firms as milk price increases lagged behind feed input increases, (2) the model (see Equation B.12) puts major weight on current feed costs and lagged milk price, and (3) the predicted value for the price of corn increased more rapidly than the actual price. Since manufacturing milk is now a very small part of California milk production and since manufacturing milk production did decrease substantially in 1974 (actual production decreased 17.43 percent from 1973 [calculated from California Crop and Livestock Reporting Service [1974a]]), this occurrence is not considered to indicate a major flaw in the model. This result did not occur in any other years in the base run. The negative values are set equal to zero in the simulation runs.

Table 16 presents the actual values for 1973 and the predicted values for 1977, 1981 and 1985 for the endogenous variables of the base model.[1/] In addition, Figure 12 illustrates the time paths of four key endogenous variables: daily market milk production, per capita consumption of class 1 products, percentage of market milk utilized as class 1 products,[2/] and average market milk price. This information is presented to illustrate the general direction projected for the endogenous variables and to serve as a basis for comparison during the discussion of the remaining simulation results.

[1/] The values are computed for the bimonthly observations but are converted to yearly values by summation or weighted averages for presentation purposes.

[2/] Percentage of market milk utilized as class 1 products is not an endogenous variable in the sector model; however, it is a good indicator of supply-demand conditions within the industry. Producers and consumers both benefit when this percentage is high: producer because a higher price results from increased utilization in high value products; consumers because a lower class 1 price is required to sustain production.

TABLE 16

Actual Values for 1973 and Predicted Values for 1977, 1981, and 1985 for the Endogenous Variables of the Base Model

Variable	Units	1973	1977	1981	1985
Daily market milk production	cwt.	256281	264746	282992	302407
Percent of market milk production in:					
Southern California	percent	34.83	33.88	32.78	31.63
Southern San Joaquin	percent	25.91	25.97	27.30	28.68
Northern San Joaquin	percent	27.24	27.98	28.49	28.89
Coast	percent	10.90	11.23	10.69	10.22
Mountains	percent	1.12	0.94	0.74	0.58
Daily manufacturing milk production	cwt.	24089	31162	21017	14095
Percent fat	percent	3.60	3.56	3.53	3.50
Percent solids	percent	8.67	8.65	8.64	8.62
Manufacturing milk price	$/cwt.	5.46	6.55	7.14	7.73
Per capita consumption of class 1 fat	lb.	8.94	8.25	7.63	7.01
Per capita consumption of class 1 skim milk	lb.	265.90	260.93	256.84	252.63
Per capita consumption of class 1 fluid	lb.	274.84	269.18	264.48	259.64
Percent of market milk utilized in class 1	percent	61.15	61.05	59.24	57.31
Fat available for products	thousand cwt.	1833	2032	2163	2329
Solids available for products	thousand cwt.	3415	3727	3765	3958
Average fat price for products	$/lb.	0.73	0.69	0.72	0.75
Average solid price for products	$/lb.	0.37	0.52	0.59	0.67
Retail value of fat in products	$/lb.	1.91	1.89	1.93	1.97
Retail value of solids in products	$/lb.	0.75	1.00	1.12	1.24
Per capita consumption of fats and solids in products	lb.	23.39	23.30	22.42	21.57
Market milk price	$/cwt.	6.50	8.38	8.99	9.65

FIGURE 12

Projections of Four Key Endogenous Variables in the Base Model

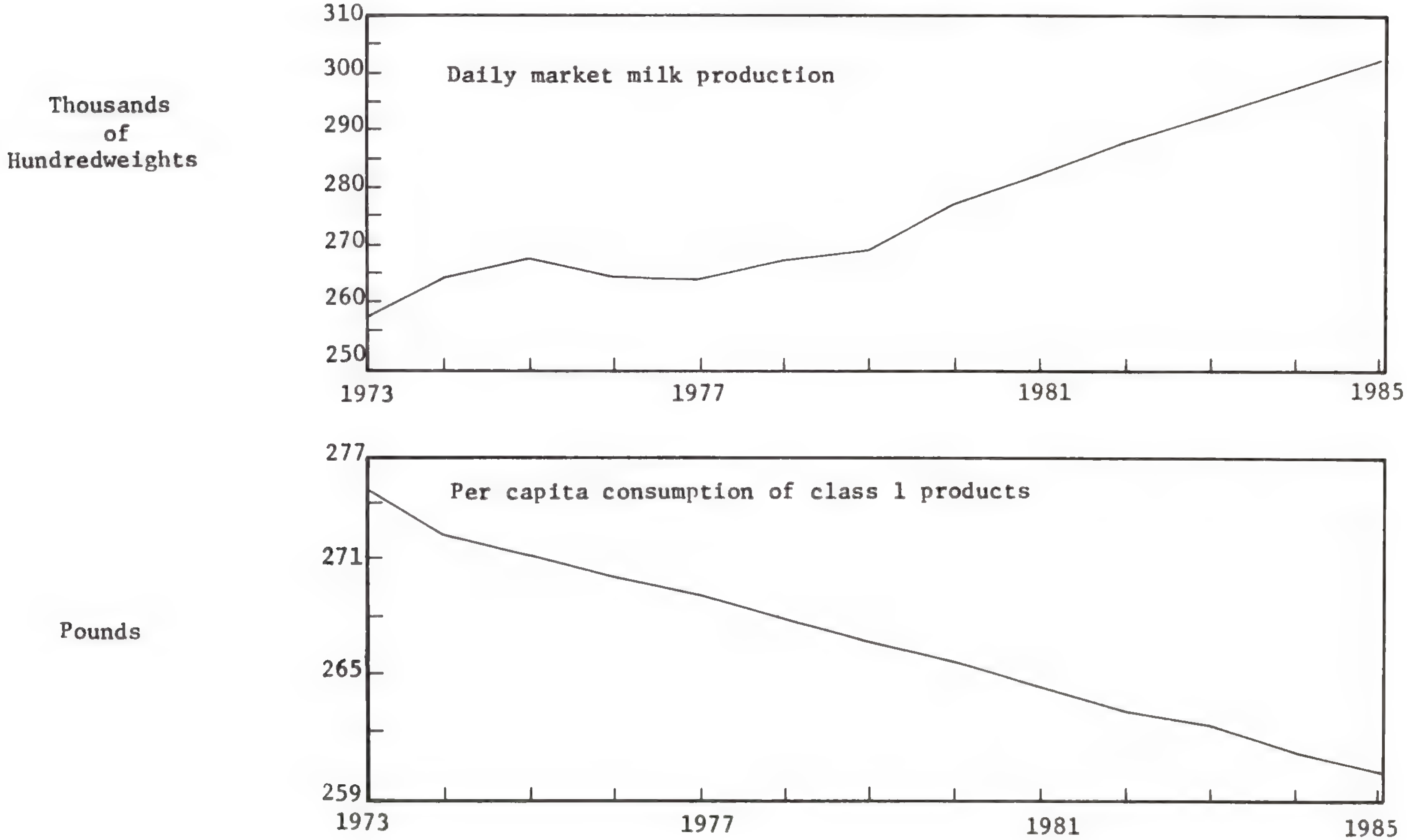
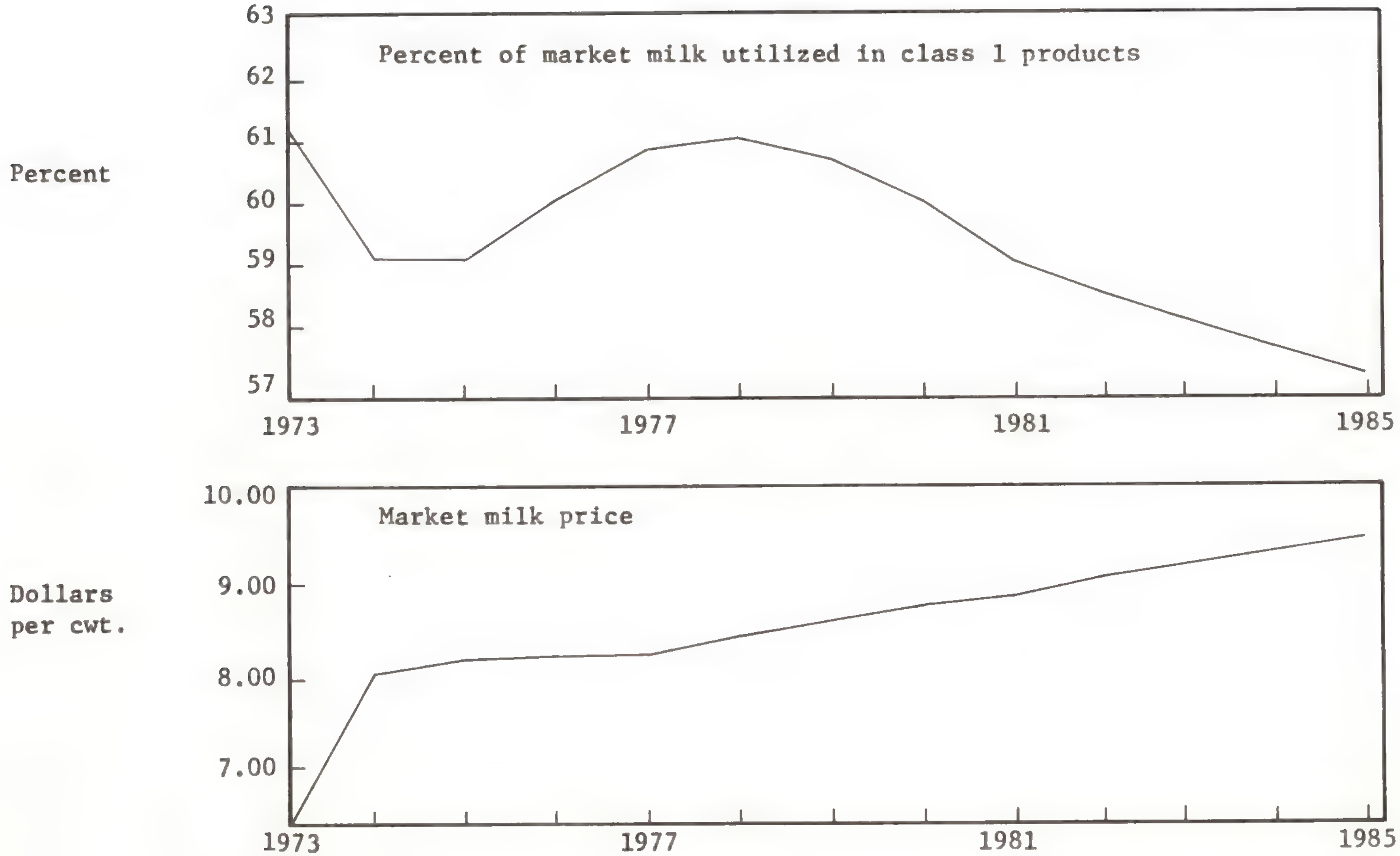


FIGURE 12 (continued)



As Figure 12 illustrates, the gradual increase that has characterized market milk production (see Figure 5) is expected to continue until 1985 except for the 1976-1977 period when production declines. This decline is a result of the reduced short-run margin in 1973-1975 when feed costs spiraled upwards. The increasing proportion of production in the Central Valley (Southern San Joaquin and Northern San Joaquin and Sacramento Valleys) illustrated in Figure 3 is expected to continue until 1985.

Actual production for 1974 and 1975 is compared to that predicted by the base model in Table 17. The simulated production is reasonably close to the actual with the largest deviations occurring toward the end of the period compared.

Since population increases do not offset the increased production and decreased per capita consumption, the percentage of market milk utilized in class 1 products declines except for the 1976-1978 period. This decline is a continuation of the past trend illustrated in Figure 6. As a result of this trend and the increased production, the quantity of fat and solids available for products is projected to increase dramatically. These production increases raise numerous questions including availability of processing capacity, competition with other farm enterprises, and relevance of the law of comparative advantage. These questions can be more adequately addressed after all simulation results have been presented. The results of the base model indicate that the price increases granted to cover the increased production costs in 1973-74 have been more than sufficient to ensure an adequate supply of milk.

The continuing shift in value from the fat component to the solids component of the milk is evidenced by the average price paid for and the retail value of fat and solids in products. The fat prices are projected to be relatively constant while solids prices increase dramatically. Both market and manufacturing milk prices increase initially as a result of the cost spiral in 1973 and 1974, level off for several years, and then increase gradually.

TABLE 17

Comparison of Actual and Simulated Daily Market Milk Production for 1974 and 1975

Period	Actual[a/] (cwt.)	Simulated (cwt.)	Percentage Deviation
1974			
Jan.-Feb.	251,911	251,614	-0.12
Mar.-Apr.	266,563	264,966	-0.60
May-June	282,167	273,581	-3.04
July-Aug.	282,117	271,555	-3.74
Sept.-Oct.	267,914	266,894	-0.38
Nov.-Dec.	255,617	259,826	+1.65
Annual	267,841	264,830	-1.13
1975			
Jan.-Feb.	257,521	261,146	+1.40
Mar.-Apr.	271,730	272,001	+0.10
May-June	288,309	278,598	-3.37
July-Aug.	288,795	272,541	-5.63
Sept.-Oct.	277,114	265,495	-4.19
Nov.-Dec.	269,484	256,092	-4.97
Annual	275,627	267,695	-2.88

[a/] Calculated from California Crop and Livestock Reporting Service [1974a, 1975a], Table 2.

In the following sections the base model is used as the basis for two types of simulations. First, the effects of price changes are investigated by various alterations in the control variables. Second, the effects of changes in key exogenous variables--population, producer costs, consumer tastes--are simulated.

Simulation Runs with Altered Control Variables

Simulation runs one through four concern changes in variables that are controlled within the dairy industry. The changes are:

1. All milk price variables are (a) increased by five percent and (b) decreased by five percent;[1/]

2. All milk price variables directly or indirectly related to the Federal milk marketing program are (a) increased by ten percent and (b) decreased by ten percent;

3. The milk price variables related to fluid milk and consequently under the effective control of the California Bureau of Milk Stabilization are (a) increased the equivalent of five cents per half gallon of fluid milk and (b) decreased the equivalent of five cents per half gallon of fluid milk;[1/]

4. The regional price differentials are (a) eliminated immediately and (b) eliminated gradually over a four year period.

Any presentation of the time paths of the endogenous variables would require many pages and would probably inundate the reader with so many graphs that little would be retained. The alternative procedure employed is to present a summary table for each simulation run. For each endogenous variable that is significantly affected by the simulated change, the following six values are presented:

1. The actual 1973 value;

2. The projected 1985 value when the first alteration of control variables (usually a decrease) is simulated;

[1/] See footnote f, p. 53. Although retail price is no longer a control variable, farm level price changes still affect retail prices. The simulation results retain validity as indicators of the effect of price changes.

3. The projected 1985 value from the base model;

4. The projected 1985 value when the second alteration of control variables (usually an increase) is simulated;

5. Percent deviation of the value under the first alteration from the base model;

6. Percent deviation of the value under the second alteration from the base model.

Interesting trends or additional items of note are presented in tables, figures, and/or the text.

Effects of Changes in All Milk Prices

The first simulation run considers the effects of a five percent increase and decrease in all milk prices whether controlled by the Bureau (control variables) or by Federal policy (exogenous variables). Eight control and exogenous variables are affected: the class 1 price for fat (C1FP), the class 1 price for skim milk (C1SP), the average price paid by manufactured dairy product processors for market milk (PFP), the average price paid by manufactured dairy product processors for market milk solids (PSP), the hundredweight equivalent of PFP and PSP (PMP), the retail price of fluid milk (RFLP), the support price for manufacturing milk (SP), and the support price for butter (SB). This simulation run is designed to measure the effect of a general increase and decrease in price and consequently profits on the California dairy industry. All other exogenous variables have the same time series as in the base model.

The results are summarized in Table 18. The five percent price changes precipitate a slight change in market milk production and a major change in manufacturing milk production. The magnitude of the changes reflect the size of the price elasticities in the sector model (see Table 10). When prices are decreased, the percentage used in fluid products decreases significantly. The opposite effects occur for price increases. Due to the inelastic demand for dairy products (see Tables 12 and 13), per capita consumption is affected only slightly.

TABLE 18

Summary of Results from Simulation Run 1: Changes in All Milk Prices

Endogenous Variable	Units	Actual 1973 amount	Projected 1985 Value			Percent Change	
			5 percent decrease	Base model	5 percent increase	5 percent decrease	5 percent increase
Daily market milk production	cwt.	256281	293009	302407	311770	- 3.11	3.10
Percentage of production in							
Southern California	percent	34.83	31.91	31.63	31.36	0.88	-0.85
Southern San Joaquin	percent	25.91	28.39	28.68	28.94	- 1.01	0.92
Northern San Joaquin	percent	27.24	28.49	28.89	29.27	- 1.38	1.31
Coast	percent	10.90	10.77	10.22	9.70	5.38	-5.07
Mountains	percent	1.12	0.43	0.58	0.72	-25.86	24.14
Daily manufacturing milk production	cwt.	24089	4285	14095	24281	-69.60	72.26
Manufacturing milk price	$/cwt.	5.46	7.30	7.73	8.13	- 5.48	5.21
Per capita consumption of class 1 fluid	lb.	274.84	260.23	259.64	259.05	0.23	-0.23
Percent of market milk utilized as class 1	percent	61.15	59.28	57.31	55.46	3.44	-3.23
Fat available for products	thousand cwt.	1833	2080	2329	2583	-10.69	10.91
Solids available for products	thousand cwt.	3415	3341	3958	4588	-15.59	15.92
Average fat price for products	$/lb.	0.73	0.71	0.75	0.78	- 4.58	4.64
Average solids price for products	$/lb.	0.37	0.64	0.67	0.70	- 4.41	4.51
Retail value of fat in products	$/lb.	1.91	1.92	1.97	2.03	- 2.93	2.96
Retail value of solids in products	$/lb.	0.75	1.18	1.24	1.30	- 4.57	4.58
Per capita consumption of fats and solids in products	lb.	23.39	21.68	21.57	21.47	0.47	-0.48
Market milk price	$/cwt.	6.50	9.20	9.65	10.09	- 4.59	4.58

After all adjustments are completed, the average market milk price changes by slightly less than five percent. The change is slightly less because the price change affects the margin and production adjustments. This production adjustment and the slight adjustment in consumption reduce the effective change in price.

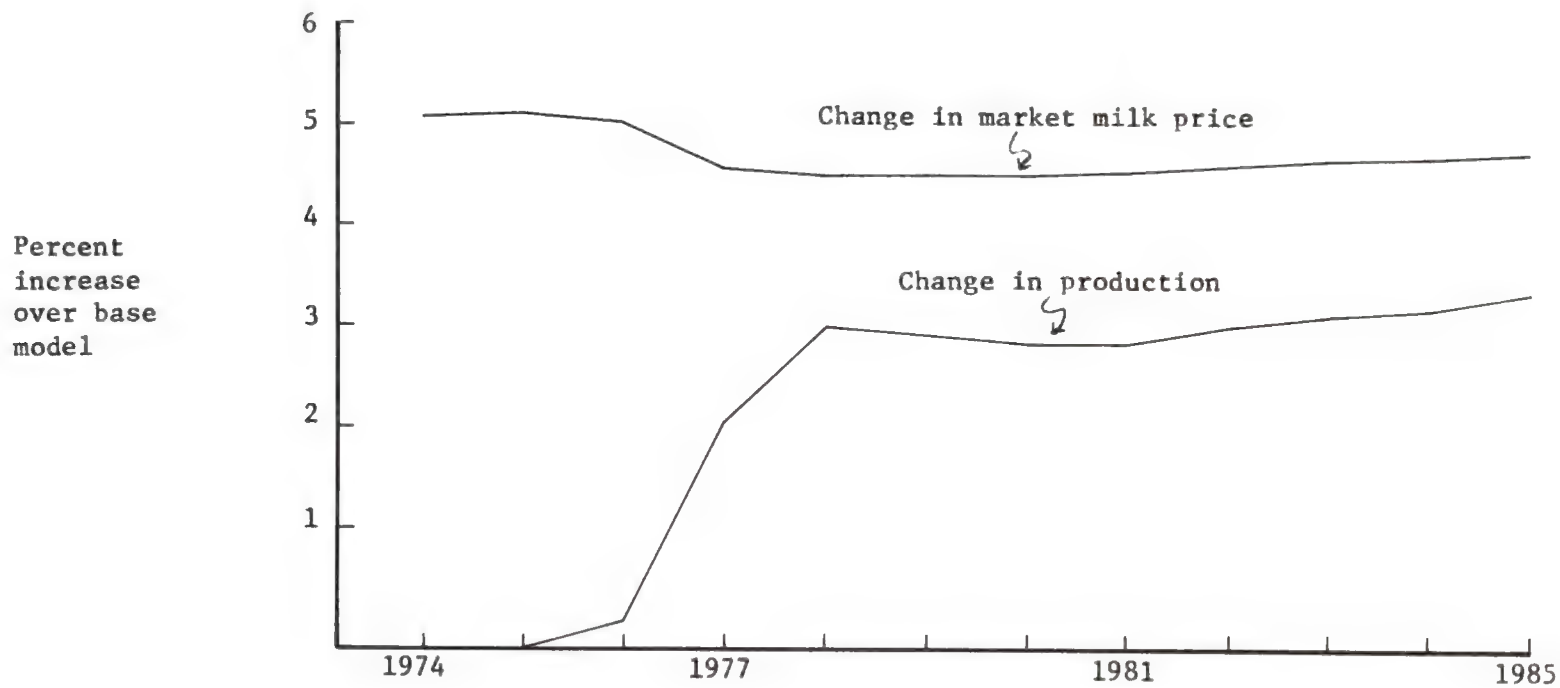
Figure 13 illustrates the time paths of production and market milk price adjustments in percentage terms for the five percent price increase. Similar changes occur for price decreases. As indicated above, the greatest price change is registered almost immediately. Significant production adjustments, however, are not registered until the third year. The percent change remains relatively constant after the fifth year. In the fourth year the percent change in price declines as the increased production affects utilization adversely. The shape of these time paths also typifies the reaction to price changes in the simulation runs that follow.

Effects of Changes in Product Prices

In the previous simulation run the effects of changes in all milk prices were illustrated. The prices can be separated into two sets of prices: (1) class 1 or fluid product prices and (2) all prices related to products. The first set of prices is the effective means of price control of the Bureau. Since products are generally transportable over long distances, these prices are directly or indirectly tied to Federal support prices. In simulation run 2 the product related prices--the average price paid by manufactured dairy product processors for market milk fat (PFP), the average price paid by manufactured dairy product processors for market milk solids (PSP), the hundredweight equivalent of PFP and PSP (PMP), the support price for manufacturing milk (SP), and the support price for butter (SB)--are decreased and increased by ten percent. All class 1 prices and retail fluid milk prices are held constant. The first three variables are controlled by the Bureau, but the price levels are tied to Federal support prices or national price levels. The final two variables are Federal support prices. This

FIGURE 13

Time Paths of Adjustment in Daily Market Milk Production and in Market Milk Price Resulting from Increasing All Milk Prices Five Percent



simulation run illustrates the influence on the California dairy industry of the prevailing U. S. prices for products.

The results from this simulation are summarized in Table 19. As can be seen by these results, the California dairy industry is definitely affected by events occurring in the national market for manufactured dairy products. The ten percent change results in a three to four percent change in market milk price. Although this change is not extremely large, the effect on profitability would be significant. This fact is illustrated by the adjustment in market milk production. The effect on manufacturing milk, which is used in products exclusively, is dramatic; the price changes by more than ten percent and production adjustments in excess of fifty percent are typical throughout the time period.

These results underscore the relatively high degree of diversification and the marginal nature of manufacturing milk dairies. These producers generally operate on a very thin margin and frequently switch to other enterprises or leave farming when that margin is reduced. Most of the production increases would probably come from increased production within existing herds; however, production decreases would come largely from liquidations of existing herds. Because individual producers may have elasticities significantly different (lower) than the aggregate, their production would not fall to zero with the price decrease, but the decrease would be very significant.

The effects recorded in the processor and consumer subsectors are limited to the products component. The quantity of fat and solids available for products is altered dramatically, especially for price increases. Some change results from market milk production adjustments, but the majority of the change comes from manufacturing milk production. Farm-level and retail prices are affected significantly, and some changes in consumption of products is projected.

Effects of Changes in Fluid Milk Prices

The more interesting control variables, because the Bureau of Milk Stabilization maintains effective control of their levels, are those

TABLE 19

Summary of Results from Simulation Run 2: Changes in All Product Prices

Endogenous Variable	Units	Actual 1973 amount	Projected 1985 Value			Percent Change	
			10 percent decrease	Base model	10 percent increase	10 percent decrease	10 percent increase
Daily market milk production	cwt.	256281	295788	302407	309328	-2.19	2.29
Daily manufacturing milk production	cwt.	24089	0	14095	34467	-100.00	144.53
Manufacturing milk price	$/cwt.	5.46	--	7.73	8.53	--	10.37
Percent of market milk utilized in class 1	percent	61.15	58.37	57.31	56.24	1.85	-1.87
Fat available for products	thousand cwt.	1833	2076	2329	2669	-10.88	14.60
Solids available for products	thousand cwt.	3415	3330	3958	4844	-15.87	22.39
Average fat price for products	$/lb.	0.73	0.68	0.75	0.82	-9.44	9.21
Average solids price for products	$/lb.	0.37	0.61	0.67	0.73	-9.18	8.96
Retail value of fat in products	$/lb.	1.91	1.85	1.97	2.09	-6.02	5.89
Retail value of solids in products	$/lb.	0.75	1.13	1.24	1.35	-9.03	9.03
Per capita consumption of fats and solids in products	lb.	23.39	22.30	21.57	20.86	3.37	-3.33
Market milk price	$/cwt.	6.50	9.32	9.65	9.99	-3.42	3.60

pertaining to class 1 or fluid products. The three variables are the class 1 price for fat (C1FP), the class 1 price for skim milk (C1SP), and the retail price of fluid milk (RFLP).[1/] When class 1 price changes are granted under the procedure described in the introductory section, the equivalent hundredweight price is changed in increments of 23 cents, which corresponds to a one cent change in the retail price of a half gallon of whole milk. To be consistent with this procedure the changes simulated are (a) a five cent decrease in the minimum retail price of a half gallon of milk, a six cent decrease in class 1 fat price, and a 94 cent decrease in the class 1 skim milk price[2/] and (b) increases of the same magnitude. Price changes of more or less than the equivalent of five cents per half gallon would have approximately proportionate effects.

The results of the changes in fluid prices are summarized in Table 20. Based on the 1985 base model values, the changes in the control variables amount to a 7.53 percent change in class 1 fat price, a 10.82 percent change in class 1 skim milk price, a 10.01 percent change in the equivalent hundredweight price for class 1 milk, and a 6.26 percent change in retail fluid milk price. These changes trigger significant changes throughout the industry. The price decrease results in a slightly larger percentage change because the lower prices result in a higher class 1 utilization; therefore, the class 1 changes affect a larger proportion of the production.

The 1985 market milk price is altered by about forty cents per hundredweight or six percent. The percent change declines gradually from slightly over eight percent. The decline emanates from production adjustments and an increasing base value with a constant change in class 1 prices. These price changes introduce a change in market milk production in excess of four percent. Production adjustments are minor in the first two years, increase quickly to almost five percent in the third and fourth year, and are almost constant in absolute terms thereafter.

[1/] See footnote 1, p. 93.

[2/] Six cents per pound of fat times 3.5 is 21 cents which added to the 94 cents makes $1.15 which is the same as a five cent retail change (5 times the 23 cent increment).

TABLE 20

Summary of Results from Simulation Run 3: Changes in Fluid Milk Prices

Endogenous variable	Units	Actual 1973 amount	Projected 1985 Value			Percent Change	
			Price decrease	Base Model	Price increase	Price decrease	Price increase
Daily market milk production	cwt.	256281	288708	302407	314904	-4.53	4.13
Per capita consumption of class 1 fluid	lb.	274.84	261.00	259.64	258.28	0.52	-0.52
Percent of market milk utilized in class 1	percent	61.15	60.34	57.31	54.75	5.29	-4.47
Fat available for products	thousand cwt.	1833	2144	2329	2500	-7.94	7.34
Solids available for products	thousand cwt.	3415	3496	3958	4384	-11.67	10.76
Per capita consumption of fats and solids in products	lb.	23.39	21.25	21.57	21.90	-1.49	1.49
Market milk price	$/cwt.	6.50	9.06	9.65	10.18	-6.08	5.55

The five percent change in utilization of market milk in class 1 products is particularly significant. This change and the opposite change in production are reflected in an even larger adjustment in fat and solids available for manufactured dairy products. This adjustment emanates entirely from market milk production since manufacturing milk production is unaffected.

Farm-level and retail product prices and values are virtually unchanged; however, a slight adjustment in per capita consumption of fats and solids in products occurs. The direction of the consumption adjustment is the same as the price change since the adjustment emanates from the substitutability of fluid milk and manufactured dairy products (see Table 13).

As can be seen by the results in Table 20, changes in fluid milk prices produce significant adjustments throughout the industry. In addition, it should be noted that a less inelastic price elasticity for fluid milk would increase the magnitude of these adjustments. Since the true elasticity is at least as large as the almost insignificant value in the sector model (see Table 12), the actual adjustments to changes in class 1 prices should be at least as large as those in Table 20.

Effects of Changes in Regional Price Differences

Although the regional price differences in market milk price are not under the direct control of the Bureau of Milk Stabilization, the California Legislature is currently considering alternatives to the current procedure for allocation of quota. Since the regional differences stem largely from the unequal regional distribution of quota (see the introductory section or Milligan [1975] for details of the current allocation procedure), the regional differences would be affected by any changes.

Recall that the regional differences are projected to decline gradually throughout the simulated period (1 percent of initial value each period in the base model). The two alternatives simulated are (a) an immediate elimination of the regional differences and (b) a linear decrease in the differences to attain elimination after four years.[1/] Since the only variables significantly affected are regional production, the usual summary table is discarded in favor of Table 21, which illustrates the regional adjustments over time. As would be expected, the movement of production into the Central Valley (Southern San Joaquin and Northern San Joaquin) is accelerated as the regional price differences are eliminated.

The elimination of the price differences also stimulates market milk production slightly as margins increase in the Valley areas and decrease in Southern California and the Coast region where production is more price inelastic. This adjustment never reaches one percent of production and falls to about a third of a percent by 1985. Subsequent minor adjustments in utilization and fats and solids available for products are also registered. Essentially no changes are registered in statewide prices and per capita consumption.

Since the aggregate effect of the regional differences is not great, the impact on the industry of changes in quota might appear to be minimal. This is probably not true because the alternative proposals have a tremendous impact on individual producers. Drastic changes, such as the first alternative, would almost certainly result in transitional adjustments not measured by the simulation model and could result in long run adjustments in addition to those predicted by the model. In addition the equity questions for individual producers must be carefully considered.

Discussion of the Effect of Price Changes

To facilitate the comparison of simulation runs 1-3, Table 22 summarizes the percentage changes resulting from general price changes, product price changes, and fluid milk price changes. The price increases are roughly similar: (1) a 5 percent general increase; (2) a 10 percent

[1/] These alternatives are designed to approximate the effect of (1) immediately allocating additional quota to bring all producers to equalization and (2) achieving this goal over a four year period. The achieving of quota equalization would not eliminate all regional price differences.

TABLE 21

Summary of Results from Simulation Run 4: The Effects on Regional Production of Changes in the Regional Price Differences

Region and Alternative	Actual 1973	Projected 1976	Projected 1979	Projected 1982	Projected 1985
		(percent of total market milk production)			
Southern California					
Base model	34.83	34.01	33.52	32.46	31.63
4 years		34.02	33.13	31.95	31.27
Immediate		33.85	32.86	31.96	31.27
Southern San Joaquin					
Base model	25.91	25.49	26.57	27.67	28.68
4 years		25.54	26.91	28.03	28.93
Immediate		25.77	27.04	28.03	28.93
Northern San Joaquin					
Base model	27.24	28.23	28.06	28.61	28.89
4 years		28.16	28.19	28.89	29.09
Immediate		28.13	28.42	28.87	29.09
Coast					
Base model	10.90	11.31	11.05	10.56	10.22
4 years		11.34	11.07	10.56	10.22
Immediate		11.37	11.04	10.56	10.22
Mountains					
Base model	1.12	0.96	0.81	0.70	0.58
4 years		0.94	0.70	0.58	0.49
Immediate		0.88	0.65	0.58	0.49

TABLE 22

A Comparison of the Effects of a General Price Change, a Change in Product Prices, and a Change in Fluid Prices

Endogenous variable	Units	Actual 1973 amount	Projected 1985 amount	Projected Change in Percent from 1985 Base Amount					
				General Price Change		Product Price Change		Fluid Price Change	
				Decrease	Increase	Decrease	Increase	Decrease	Increase
Daily market milk production	cwt.	256281	302407	- 3.11	3.10	- 2.19	2.29	- 4.53	4.13
Daily manufacturing milk production	cwt.	24089	14095	-69.60	72.26	-100.00	144.53	0	0
Manufacturing milk price	$/cwt.	5.46	7.73	- 5.48	5.21	--	10.37	0	0
Per capita consumption of class 1 fluid	lb.	274.84	259.64	0.23	- 0.23	0	0	0.52	- 0.52
Percent of market milk utilized as class 1	%	61.15	57.31	3.44	- 3.23	1.85	- 1.87	5.29	- 4.47
Fat available for products	thousand cwt.	1833	2329	-10.69	10.91	- 10.88	14.60	- 7.94	7.34
Solids available for products	thousand cwt.	3415	3958	-15.59	15.92	- 15.87	22.39	-11.67	10.76
Average fat price for products	$/lb.	0.73	0.75	- 4.58	4.64	- 9.44	9.21	0	0
Average solids price for products	$/lb.	0.37	0.67	- 4.41	4.51	- 9.18	8.96	0	0
Retail value of fat in products	$/lb.	1.91	1.97	- 2.93	2.96	- 6.02	5.89	0	0
Retail value of solids in products	$/lb.	0.75	1.24	- 4.57	4.58	- 9.03	9.03	0	0
Per capita consumption of fats and solids in products	lb.	23.39	21.57	0.47	- 0.48	3.37	- 3.33	- 1.49	1.49
Market milk price	$/cwt.	6.50	9.65	- 4.59	4.58	- 3.42	3.60	- 6.08	5.55

increase for 45 percent of the 1985 base model production (manufacturing production and market production diverted to products); and (3) approximately a 10 percent increase on 55 percent of the 1985 base model production (market milk for fluid use).

Since, in general, the prices for manufacturing milk and manufactured dairy products are affected by Federal policies and national markets for products while market milk prices, particularly fluid milk prices, are affected by decisions made by the Bureau of Milk Stabilization, the discussion focuses on market milk and fluid milk prices. Three items are particularly noteworthy: (1) the importance of pricing decisions; (2) the impact on producers and consumers of price changes; and (3) the relevance of the law of comparative disadvantage.

Because of the extremely inelastic short run response in supply and demand, price adjustments must be made with extreme caution. If an adjustment over- or undershoots the mark, subsequent readjustments to correct the original error may take years. Although one of the stated criteria for setting milk prices is to maintain an adequate future supply of milk, little consideration is given to long run implications during the price-setting process. The correction of this deficiency could significantly improve the pricing decisions made by the Bureau of Milk Stabilization.

During debate over some issues concerning agriculture, producers and consumers have aligned themselves using the argument that a healthy producing sector is in the long run best interest of consumers. Such harmony has not existed in the hearings for producer price adjustments; in fact consumer groups have vigorously opposed recent producer proposals. The results of the simulations suggest that this confrontation is to be expected since producer and consumer interests appear to be in conflict in both the short and long run. Because the market milk that is not needed for fluid needs goes into manufactured dairy products where quantity changes in California have little price impact, price increases result in increased producer profits in both the short and long run. In no simulation did the fluid demand come close to utilizing the available supply of market milk. Since added production has little if any affect on retail prices for manufactured dairy products, the consumer has virtually nothing to gain in the short or long run from price increases. The confrontation between producers and consumers will undoubtedly continue.

The final point for discussion concerns the advisability of large scale production of milk for manufactured dairy products and the relevance of the law of comparative advantage.[1/] In the absence of controls this economic relationship would determine the quantities of milk produced in California for fluid and product uses. There is little question that production to meet fluid and perishable product needs--both actual and excess to meet daily and seasonal fluctuations--should remain in California. The question of whether fertile, irrigated land capable of growing specialty crops, cotton, tomatoes, etc., should be used to grow roughage to be used to produce milk for butter, cheese, etc. should be answered by the law of comparative advantage.

Unfortunately, the law of comparative advantage cannot operate effectively under the present procedure for setting prices: prices for products are administratively aligned with those prevailing throughout the country and class 1 or fluid prices are then established at a level that will result in the desired average market milk price. Since all simulations provide adequate supplies of milk to meet fluid demands, the decisions made regarding fluid milk prices will actually determine the quantity of milk available for processing into products. Consequently, explicit consideration of California's relative advantage in production of milk for the storable products should be carefully considered and the conclusions used in setting class 1 prices.

Policy-makers should consider the possibility of adopting a pricing policy that would attempt to maintain production at a level consistent with a pre-established target level for percent of market milk utilized in class 1 products. The target level would be established after considering comparative advantage, producer interests, and consumer

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[1/] The law of comparative advantage states that an enterprise will be located in the region that has the largest relative economic advantage or the least relative economic disadvantage in its production.

interests. These simulation runs raise serious questions about a continuation of the present pricing policy which encourages production of milk for manufactured dairy products that probably should remain in the Great Lakes and Northeast and which appears to favor producers at the expense of consumers.

Simulation Runs with Altered Exogenous Variables

Three simulation runs (numbers 5-7) are executed to illustrate the effects of exogenous variables on the California dairy industry. The three runs trace the effects of changes in variable costs incurred by producers, the population growth rate, and consumer tastes for fluid milk. The format for the presentation of results is the same as in the previous section.

Effects of Changes in Variable Costs of Producers

Simulation run 5 is devised to measure the effects on the California dairy industry of exogenous changes in variable costs, most likely in the form of altered feed costs. The effects are measured by simulating (a) a five percent decrease in each of the regional variable cost and corn price variable and (b) a five percent increase in the same variables. Table 23 summarizes the effect of changes in production costs.

A comparison of the cost changes with the five percent price changes (Table 22) indicates that market milk production adjustments are similar but that manufacturing milk production adjustments to cost change are significantly less than to price changes. The production adjustments affected utilization of market milk and the quantity of fat and solids available for products; however, consumption remained constant and prices were unchanged with the exception of a very minor change in market milk price due to the change in utilization.

TABLE 23

Summary of Results from Simulation Run 5: Changes in Variable Costs of Producers

Endogenous variable	Units	Actual 1973 amount	Projected 1985 values			Percent change	
			Cost decrease	Base model	Cost increase	Cost decrease	Cost increase
Daily market milk production	cwt.	256281	311097	302407	293749	2.87	-2.86
Percentage of production in							
Southern California	%	34.83	31.42	31.63	31.85	-0.66	0.71
Southern San Joaquin	%	25.91	28.92	28.68	28.43	0.84	-0.88
Northern San Joaquin	%	27.24	29.23	28.89	28.53	1.18	-1.24
Coast	%	10.90	9.73	10.22	10.74	-4.79	5.10
Mountains	%	1.12	0.71	0.58	0.45	22.41	-23.18
Daily manufacturing milk production	cwt.	24089	15023	14095	13168	6.58	-6.58
Percent of market milk utilized in class 1	%	61.15	55.71	57.31	59.00	-2.79	2.94
Fat available for products	thousand cwt.	1833	2454	2329	2207	5.27	-5.26
Solids available for products	thousand cwt.	3415	4262	3958	3657	7.65	-7.62
Market milk price	$/cwt.	6.50	9.61	9.65	9.68	-0.35	0.37

Effects of Changes in Population Growth Rate

The California Department of Finance [1974a] has released four alternative population projections for California. The baseline projection is specified in the base model. In simulation run 6 (a) the low alternative (series E-0, population of 22,575,000 on July 1, 1985) and (b) the high alternative (series C-150, population of 25,159,000 on July 1, 1985) are linearized and the effects compared to the baseline population projections (24,363,000 on July 1, 1985). Table 24 summarizes the results.

The primary impact of population growth is on the utilization of the market milk production. The greater the increase in population growth, the larger the consumption of fluid products, and the smaller the quantity of fats and solids available for products. Since this improved utilization of market milk increases market milk price slightly, production is also increased by a very small amount.

The impact of population change is felt gradually because the population time paths deviate only slightly at first. The percent changes of the variables in Table 24, gradually increase through the time period, and reach a maximum in 1985. This gradual change is not exhibited by any of the previously considered changes.

Effects of Changes in Consumer Tastes for Fluid Milk

As evidenced by the strong negative time trend in the equations for fluid fat and skim milk (see Equations B.24 and B.25, page 71), consumer tastes have been turning from milk to other beverages. The future course of this trend has important implications for the California dairy industry. In the base model the downward trend in consumer tastes for fluid milk is projected to continue. In simulation run 7 the effects of (a) a gradual reduction in downward trend of tastes[1/] and (b) a

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[1/] The gradual reduction is simulated by taking the square root of the portion of the time trend occurring during the simulation period.

TABLE 24

Summary of Results from Simulation Run 6: Changes in Population Growth Rate

Endogenous variable	Units	Actual 1973 amount	Projected 1985 values			Percent change	
			Slower growth	Base model	Faster growth	Slower growth	Faster growth
Daily market milk production	cwt.	256281	301142	302407	303031	-0.42	0.21
Percent of market milk utilized in class 1	percent	61.15	53.76	57.31	59.06	-6.19	3.05
Fat available for products	thousand cwt.	1833	2426	2329	2282	4.16	-2.03
Solids available for products	thousand cwt.	3415	4315	3958	3782	9.02	-4.44
Market milk price	$/cwt.	6.50	9.57	9.65	9.69	-0.77	0.38

leveling off of tastes at 1973 levels are simulated. The results are summarized in Table 25.

As with the population changes simulation, the effects of changing consumer tastes are manifested primarily in the utilization of market milk. The change in utilization is caused by increased per capita consumption rather than by population growth. Again, changes occur gradually over time.

Discussion of Simulation Runs

The increase in market milk production and decrease in fluid utilization characterize all simulation runs. Table 26 summarizes the results of all simulation runs except regional differences for the alternative that is most favorable to dairymen. The other alternative would produce the opposite result in all instances, except changes in consumer tastes. As can be seen from this table, market milk price has the greatest impact on production while market milk price and the exogenous factors affecting demand have large impacts on the percent of market milk utilized as class 1. The implications for pricing policy were discussed following the price changes (simulation runs 1-4); in this section other impacts of the increased production are discussed.

The most important question is how will the additional capacity at all levels be acquired. At the producer level the additional capacity will come primarily from continued expansion of presently operating herds.

The more interesting question concerns processing the increased quantities of fats and solids available for manufactured dairy products for which new processing plants will probably be required. Since cheese production is presently minor in California and since cheese producers are interested in building in California because of relatively high levels of solids, the potential for increased production of cheese is good.

TABLE 25

Summary of Results from Simulation Run 7: Changes in Consumer Tastes for Fluid Milk

Endogenous variable	Units	Actual 1973 amount	Projected 1985 values			Percent change	
			Base model	Gradual decrease	Constant tastes	Gradual decrease	Constant tastes
Daily market milk production	cwt.	256281	302407	303217	303350	0.27	0.31
Per capita consumption of class 1 fluid	lb.	274.84	259.64	273.50	275.39	5.34	6.07
Percent of market milk utilized in class 1	%	61.15	57.31	60.21	60.60	5.06	5.73
Fat available for products	thousand cwt.	1833	2329	1988	1942	-14.66	-16.65
Solids available for products	thousand cwt.	3415	3958	3664	3625	-7.45	-8.44
Market milk price	$/cwt.	6.50	9.65	9.70	9.70	0.52	0.59

TABLE 26

Summary of the Effects of Changes in Selected Control and Exogenous Variables

Endogenous variables	Percent change from the 1985 base value resulting from a					
	5 percent increase in milk prices	10 percent increase in product prices	5 cent per half gallon increase in fluid prices	5 percent decrease in variable costs	Increased population growth rate	Leveling off of downward trend in fluid milk consumption
Daily market milk production	3.10	2.29	4.13	2.87	0.21	0.31
Per capita consumption of fluid milk	-0.23	--[a]	-0.52	0	0	6.07
Percent of market milk utilized as class 1	-3.23	-1.87	-4.47	-2.79	3.05	5.73
Market milk price	4.58	3.60	5.55	-0.35	0.38	0.59

[a] Value is close to zero.

SUMMARY AND CONCLUSIONS

Milk price increases necessitated by increases in recent years in feed and other costs incurred by dairymen have focused the attention of producers and consumers in California on the important role of the State of California in establishing milk prices. To provide additional economic input into the procedure employed to establish producer prices, an econometric model of the California dairy industry using bimonthly observations for 1958-1973 was developed. This model was used to simulate the effects of changes in price and other key variables.

Six supply response functions were estimated in the producer subsector: five regional equations for market milk and one statewide equation for manufacturing milk. Returns to producers were introduced by separate variables for average short-run margin per cow for each of the last four years. The results exhibited minimal short-run response to margin per cow. The overall price response was inelastic in the four regions where most dairies are large and specialized; in the remaining two equations, where most producers are smaller and more diversified, an elastic response was indicated. Significant responses were also found for variables reflecting the opportunity cost of the dairyman's capital and labor, for dummy variables for seasonality of production, and for proxy variables for improvements in management, technology, and genetic ability.

In the consumer subsector demand equations were estimated for fluid and manufactured dairy products. All equations were characterized by inelastic responses to price and income; the demand for fluid products was more inelastic with little significance in the coefficients. Fluid consumption is affected significantly by other factors including seasonality, a downward trend in consumption, and a proxy variable for consumers' concern over the cholesterol content of milk. The demand for fats and solids in products was also characterized by seasonality and by a downward trend in consumption.

Due to the control exerted by the State of California, most of the relationships in the processor subsector are identities; behavioral equations were estimated for manufacturing milk price in California and marketing margin equations for milkfat and solids-not-fat in manufactured dairy products. The manufactured milk price was found to be very closely aligned with the controlled price for market milk used in manufactured dairy products. The margin equations exhibited a combination of absolute and percentage markups, a significant response to increased labor costs, and a ceteris paribus decrease in margin over time.

Simulation runs indicate that increases in the supply of milk will exceed any increases in fluid demand for the foreseeable future. All simulation runs predicted rather large increases in market milk production, decreases in the percentage of market milk utilized as class 1, and increases in fats and solids available for products. Changes in key variables including prices paid producers for milk, variable costs incurred by producers, population growth rates, and consumer tastes for fluid milk indicated that the proportion of market milk used for fluid products and the quantity of milkfat and solids-not-fat available for manufactured dairy products are particularly sensitive to all changes. The simulation results indicate that recent price increases are sufficient to maintain adequate supplies of fluid milk and that requests for additional increases should be thoroughly investigated.

Although little problem is anticipated in expanding capacity to handle the increased production, two issues should be addressed by policy-makers who set the prices that could result in the increase. The first issue is whether milk production for use in storable (and transportable) dairy products should be expanded in California where the land required for roughage could be used for specialty crops, etc. The second issue is that with the adequate supply of milk and inelastic demand, price increases are almost totally passed on to consumers.

Future research related to this model could be centered in three areas. The first is to refine the estimates in the structural model particularly the short-run supply response to price and the demand for dairy products. The simulation model itself could be altered so that a policy maker could specify the desired producer margin or production, and the model would determine the price levels required to meet the desired goal. A third and less directly related issue would be an analysis of the comparative advantage question relative to storable products.

APPENDIX A. DATA SOURCES

In this appendix the sources of all data utilized are indicated and any transformations performed on the original data are outlined. Unless noted otherwise, the data are for 1958-1973. The data required for the producer subsector are discussed first. Most bimonthly prices are simple or weighted averages of monthly prices.

Data for the Producer Subsector

Since supply functions for market milk are estimated for five regions of the state, a j subscript indicates the data are collected for each of the five regions. The five regions are:

1. Southern California
2. Southern San Joaquin Valley
3. Northern San Joaquin and Sacramento Valleys
4. Central Coast
5. Mountain Areas and North Coast

The map in Figure 2, page 8, shows the location of the five regions.

Quantity Produced

q^A : Designation - Production of market milk.
Source - California Crop and Livestock Reporting Service [1959-1974], Table 7, 1958-1960; Table 8, 1961-1973.
Transformations - Summation of monthly production.

q^A_j : Designation - Production of market milk in region j.
Source - Same as q^A.
Transformation - Summation of monthly production in counties in region j.

q^B : Designation - Production of manufacturing milk.
Source - California Crop and Livestock Reporting Service [1959-1974], Table 8, 1958-1960; Table 9, 1961-1973.

Prices Received by Producers

p^A : Designation - Average price paid for market milk in California.

Source - California Crop and Livestock Reporting Service [1959-1974], Table 15, 1961; Table 14, 1973.

Transformations - Weight monthly prices by market milk production.

p_j^A : Designation - Average price paid for market milk in region j.

Source - Same as p^A and Agricultural Commissioner Annual Report [1958-1974].

Transformations - The prices received by market milk producers in the counties in the regions are weighted by county production to give a regional yearly price. The bimonthly prices are arrived at by incorporating the yearly trend of the state price into the regional annual price. These prices are then refined so that the regional prices are consistent with the state average price.

p^B : Designation - Average price paid for manufacturing milk.

Source - California Crop and Livestock Reporting Service [1959-1974], Table 16, 1961; Table 15, 1973.

Transformations - Weight monthly prices by manufacturing milk production.

Standard Cost of Production Data[1/]

sct_j^1 : Designation - Average feed cost per hundredweight in region j.

Source - California Bureau of Milk Stabilization [First quarter 1958--Nov.-Dec. 1974].

Transformations - Average of cost regions in region j weighted by production in each cost region.

[1/] The standard cost of production data are taken from surveys conducted by the Bureau of Milk Stabilization. Although the surveys are not conducted on a random basis, they are considered to be representative. The aggregation of these regions into the five used in this study is detailed in Milligan [1975a].

sct^1 : Designation - Average feed cost per hundredweight for market milk producers.

Source - Same as sct_j^1.

Transformations - Average of five regions weighted by production in each region.

Note: For the remainder of this subsection the source and transformations are the same as above.

sct_j^2 : Designation - Average labor cost per hundredweight in region j.

sct^2 : Designation - Average labor cost per hundredweight for market milk producers.

sct_j^3 : Designation - Average miscellaneous cost per hundredweight[1/] in region j.

sct^3 : Designation - Average miscellaneous cost per hundredweight[1/] for market milk producers.

PPC^j : Designation - Average production per cow in region j.

<u>Other Data</u>

p^{BF} : Designation - Average price received by California beef producers (dollars per cwt.)

Source - California Crop and Livestock Reporting Service [1960b], Table 41, 1958; California Crop and Livestock Reporting Service [1970b], 1959-1969; and California Crop and Livestock Reporting Service [1970c-1975c], 1970-1975.

Transformations - Simple average of the two months in the bimonthly period.

p^{CORN} : Designation - Average price received per hundredweight by California corn growers.

1/ This miscellaneous cost is not the miscellaneous cost in the survey. It is taxes and insurance + operating costs + marketing costs - miscellaneous income.

Source - California Crop and Livestock Reporting Service [1960b], Table 2, 1958; California Crop and Livestock Reporting Service [1970b], 1959-1969; and California Crop and Livestock Reporting Service [1970c-1975c], 1970-1975.

Transformations - Simple averages.

p^L : Designation - Index of average farm real estate value per acre, California (1967=100).

Source - United States Department of Agriculture [1973b], page 11, 1958-1972; and United States Department of Agriculture [1974b], Table 1, 1973.

Transformations - March index is used for first three bimonthly periods and November index for the last three of each year.

p^{INT} : Designation - Bank interest rates on short-term business loans.

Source - An item titled "Finance-Banking, Money and Interest Rates, Bank Rates on Short-Term Business Loans, (a) in 19 cities (1958-1966), (b) in 35 centers (1967-1973)" in United States Department of Commerce [1959-1973, biennial], 1958-1972; and United States Department of Commerce [1973a-1975a], 1973-1975.

Transformations - Quarterly data converted to bimonthly with bimonthly observations 1, 3, 4, 6 corresponding to the quarters, observation 2 is the average of quarters 1 and 2, observation 5 of quarters 3 and 4.

dhi : Designation - Percentage of cows on DHI test.

Source - California Crop and Livestock Reporting Service [1959-1974], Table 1 and University of California [1974].

Transformations - Divide average number of cows on test by estimated number of cows in the state. Percentage serves for the six bimonthly observations for the year.

Data for the Processor and Consumer Subsectors

In this section the sources of the data used in the specification of the processor and consumer subsectors are indicated. The data series are statewide and begin in 1958. The variable production per cow (PPC^j) and price received for manufacturing milk (p^B) are not described below since they appear in the previous section.

Control Variables

C1FP : Designation - Average price per pound processors paid producers for fat used in class 1 products.

Source - California Crop and Livestock Reporting Service [1959-1974], Table 26, 1958; Table 25, 1959-60; Table 21, 1961-72; Table 20, 1973; California Crop and Livestock Reporting Service [1958a-1969a], Table (inside back cover) titled: "Minimum Class 1 Prices as of _____", California Crop and Livestock Reporting Service [1969a-1974a], table titled, "Monthly Statistical Summary of California Milk Pool Data", and California Bureau of Milk Pooling [1974a].

Transformations - To obtain bimonthly observations prior to July 1969, the price paid for fat in each marketing region (California Crop and Livestock Reporting Service [1958a-1969a]) is weighted by the class 1 sales of fat in each marketing region (California Crop and Livestock Reporting Service [1959-1970]). To calculate the series after July 1969, the monthly class 1 pool price for fat (California Bureau of Milk Pooling [1974a]) is weighted by the utilization in the two months (California Crop and Livestock Reporting Service [1969a-1974a]).[1/]

[1/] Due to the changes instituted in July 1969 with the implementation of statewide milk pooling, each procedure correctly calculates the price.

C1SP : Designation - Average price per hundredweight processors paid producers for skim milk used in class 1 products.

Source - All of the sources listed for C1FP plus California Crop and Livestock Reporting Service [1959-1974], Table 36, 1958-1960; Table 24, 1961-72; Table 23, 1973 and California Bureau of Milk Pooling [1971-1974].

Transformations - To obtain bimonthly observations prior to July 1969, the price paid for skim milk in each marketing region (California Crop and Livestock Reporting Service [1958a-1974a]) is weighted by the class 1 sales of fluid milk minus class 1 sales of fat in each region (California Crop and Livestock Reporting Service [1959-1974]). To complete the data series, the price of skim milk in each month is derived from the price of class 1 solids (California Bureau of Milk Pooling [1974a]) using the percentage solids in skim milk (California Bureau of Milk Pooling [1971-1974]).[1/] The monthly price is then weighted by the quantity of solids sold as class 1 (California Crop and Livestock Reporting Service [1969a-1974a]).

RFLP : Designation - Average minimum retail price for a half gallon of milk.

Source - California Crop and Livestock Reporting Service [1959-1974], Table 36, 1958-60; Table 24, 1961-72; Table 23, 1973 and California Crop and Livestock Reporting Service [1969a-1974a], Table (inside back cover) titled: "Minimum Class 1 Prices as of _____".

[1/] The formula pct. solids = .444 x pct. fat + 7.07 was used for July 1969-December 1970 observations.

Transformations - Retail price of a half gallon of milk in each marketing region weighted by the class 1 sales in that region.[1/]

PFP : Designation - Average price paid by processors for market milk fat used in manufactured dairy products (classes 2, 3, and 4).

Source - California Bureau of Milk Stabilization [1958a-1969a], California Crop and Livestock Reporting Service [1969a-1974a], and California Bureau of Milk Pooling [1974a].

Transformations - To obtain observations since 1969, the average price of fat in each class (California Bureau of Milk Pooling [1974a] is weighted by the utilization in each class (California Crop and Livestock Reporting Service [1969a-1974a]). For observations prior to July 1969 neither an average statewide price for class 2 and 3 fat (class 4 was not created until July 1969) nor the utilization in each class was compiled. In this absence the price for class 2 and class 3 fat sold in the Central Valley was combined in a manner consistent with utilization after July 1969.

PSP : Designation - Average price paid by processors for market solids used in manufactured dairy products (classes 2, 3, and 4).

Source - Same as PFP.

Transformations - Same as PFP using solids. Prior to July 1969 skim milk price was converted to a price for solids.

[1/] This price series is not precise price measure since not all fluid milk is sold as half gallons of milk nor is all milk sold at the minimum price; however, the series is representative of retail class 1 prices.

Endogenous Variables

PCF : Designation - Percentage fat in milk produced in California.

Source - California Crop and Livestock Reporting Service [1959-1974], Table 6 and 9, 1958-61; Tables 7 and 10, 1962-1973.

Transformations - Division of total fat production by total milk production.

PCS : Designation - Percentage solids-not-fat in milk produced in California.

Source - California Bureau of Milk Pooling [1974b].

Transformations - The percentage solids is derived from the percentage fat by a formula, referred to by Bureau personnel as "Dr. Jack's Formula",

$$PCS = 7.07 + .444 \times PCF$$

Note: The sources and transformations for the following four variables are included in one description following the designation of the four variables.

RFP : Designation - Retail price of the milkfat purchased in manufactured dairy products.

RSP : Designation - Retail price of the solids-not-fat purchased in manufactured dairy products.

RFQM : Designation - Per capita quantity of fat purchased in manufactured dairy products.

RSQM : Designation - Per capita quantity of solids purchased in manufactured dairy products.

Source - United States Department of Labor [1958-1974], California Crop and Livestock Reporting Service [1974], Table 66, Hiemstra [1968], Table 11, United States Department of Agriculture [1974], Table 11, United States Department of Agriculture [1973c], Table 4 and 5, pages 10-13, Fallert [1973a], and United States Department of Agriculture [1959d-1974d].

Transformations - Since manufactured dairy products are not purchased as fats and solids, the retail value of the fats and solids must be derived from the retail prices and quantities of the various manufactured dairy products, the proportions of fats and solids in these products, and the price paid (to the producer) for fat and solids by the processor. Estimated monthly prices for evaporated milk, ice cream, American Processed cheese, and butter in San Francisco and Los Angeles are available (U. S. Department of Labor [1958-1974]). The yearly per capita consumption of buttermilk, ice cream, and cottage cheese is calculated for California (California Crop and Livestock Reporting Service [1974]) and national averages are obtainable for the remaining manufactured dairy products (Hiemstra [1968] and United States Department of Agriculture [1974]). The yearly per capita consumption is separated into the six bimonthly periods according to seasonal consumption in the Western U. S. (U. S. Department of Agriculture [1973c]).[1/] The total quantity of fats and solids purchased in manufactured dairy products is calculated by multiplying the proportion of fat and solids (Fallert [1973a]),[2/] the per capita yearly consumption, and the proportion consumed in the appropriate bimonthly period. The retail

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[1/] The data in the survey are reported by quarters. These quarters are converted to bimonthly periods as follows: bimonthly periods 1, 3, 4, and 6 come directly from the quarters, bimonthly period 2 is the average of quarters 1 and 2, and bimonthly period 5 is the average of quarters 3 and 4. The consumption in these periods is then converted to the proportion of the yearly consumption in each period.

[2/] In addition to the information in Fallert [1973a], the ratio of ice cream mix to ice cream was required (U. S. Department of Agriculture [1959d-1974d]).

prices of fat and solids in the four products for which prices are available are derived by dividing the retail price per pound of the product (the simple average of the price in San Francisco and Los Angeles in each of the two months adjusted to one pound) by the value of the fats and solids included in the product (proportion fat x APF + proportion solids x APS). This markup constant is then multiplied by APF and APS to obtain a retail value of fat and solids in each of the four products. These four prices are then weighted by the quantity of fats and solids consumed in products similar to the four possessing retail prices.[1/]

RFQF : Designation - Per capita quantity of fat processed and sold in fluid (class 1) products.

Source - California Crop and Livestock Reporting Service [1959-1974], Table 26, 1958; Table 25, 1959-60; Table 21, 1961-72; Table 20, 1973.

Transformations - The total quantity of fat sold in class 1 products in the two month period is divided by the estimated population (POP).

SD : Designation - Support price, cents per pound, for nonfat dairy milk, extra grade, spray.

Source - United States Department of Agriculture [1968f], Table 84, p. 102, and United States Department of Agriculture [1974h], Table 5, p. 11.

Transformations - Use price prevailing during bimonthly period. When the support level changes during the period, the prices were weighted by the days each price prevailed.

[1/] The price of fats and solids in evaporated milk is weighted by the quantity of fats and solids in evaporated whole milk, evaporated and condensed skim milk, condensed whole milk--sweetened, condensed whole milk--unsweetened, nonfat dry milk, dry whole milk, dry buttermilk, dry whey and malted milk; ice cream is weighted by buttermilk, ice cream, ice milk, sherbert, imitation ice cream, and imitation ice milk; American processed cheese is weighted by cottage cheese, low fat cottage cheese, American cheese, and other cheese; and butter is weighted by butter.

XMCH : Designation - Average hourly earnings of production and related workers in manufacturing, dairy products.

Source - California Department of Industrial Relations [1959-1971], California Department of Human Resources Development [1972], and California Employment Development Department, [1973-74].

Transformations - Simple average of the earnings in the two months.

Y : Designation - Per capita personal income in the U. S. at a seasonally adjusted annual rate.

Source - United States Department of Commerce [1973], "Personal Income, Total", p. 206, and "Population, U. S. Total", p. 240, and United States Department of Commerce [1973a-1974a], items titled "General Business Indicators - Monthly Series, Seasonally Adjusted, at Annual Rate, Total Personal Income" and "Labor Force, Employment and Earnings, Population of the United States, Total, Including Armed Forces Overseas".

Transformations - Average total personal income for the two months divided by the average population.

POP : Designation - Estimated total population of California.

Source - California Department of Finance [1959-1974], Table titled: "Estimated Total and Civilian Population of California, Total Population (July 1)".

Transformations - The bimonthly populations are derived by assuming the change from July 1 to the following July 1 is linear.

AD : Designation - Proportion of the California population enrolled in kindergarten through grade eight.

Source - California Department of Finance [1959-1974], Table titled: "Estimated and Projected Enrollment in Kindergarten and Grades 1-12, California Public Schools, Kindergarten through Grade Eight".

Transformations - Enrollment divided by population serves for six bimonthly periods.

XIMIT: Designation - Per capita consumption of imitation dairy products.

Source - California Crop and Livestock Reporting Service [1959-1974].

Transformations - Percentage of class 1 sales from California Crop and Livestock Reporting Service [1959-1974] times per capita consumption of class 1 products.

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